SUCCESSES IN AFRICAN AGRICULTURE: RESULTS OF AN EXPERT SURVEY

by

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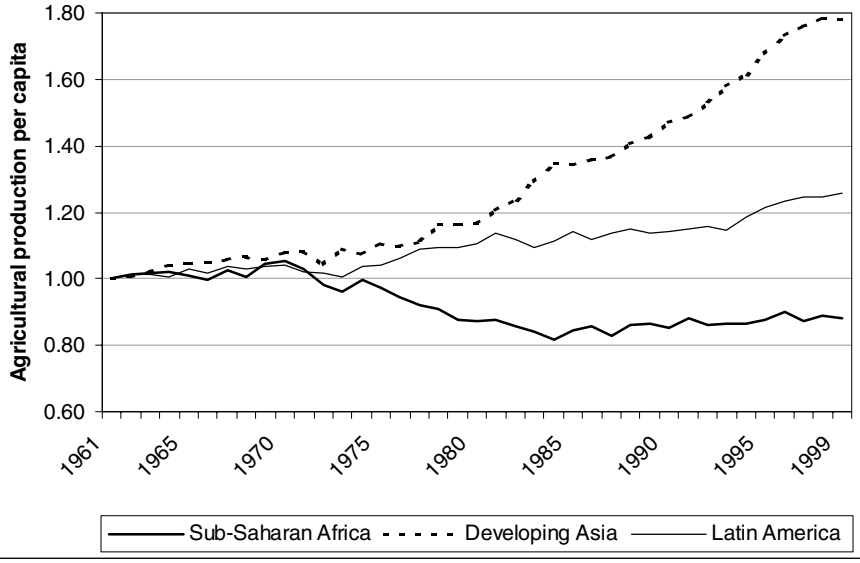
1. IMPERATIVES AND OBJECTIVES

Agricultural growth will prove essential for improving the welfare of the vast majority of Africa's poor. Roughly 80% of the continent's poor live in rural areas (Sahn et al., 1997; World Bank, 2000). And even those who do not will depend heavily on increasing agricultural productivity to lift them out of poverty. As producers, 70% of all Africans -- and nearly 90% of their poor -- work primarily in agriculture (World Bank, 2000). Trends in farm production and productivity, therefore, largely govern their earnings momentum. As consumers, all of Africa's poor -- both urban and rural – count heavily on the efficiency of the continent's farmers. Farm productivity and production costs prove fundamental determinants of the prices of cassava, maize, sorghum, millet and other basic foodstuffs which account for 60% to 70% of total consumption expenditure by low-income groups (Sahn et al, 1997). Indeed, the current structure of income and consumption among the African poor suggests that significant reductions in poverty will hinge in large part on the collective ability of African farmers, governments and agricultural specialists to stimulate and sustain broad-based agricultural growth.

Farm production across the continent has changed considerably since the beginning of domesticated agriculture in Africa, seven thousand years ago. Following the initial domestication of pearl millet and sorghum, about 5,000 BC in what was then an abundantly watered Sahel, African women and men have domesticated a series of other important indigenous crops such as coco yams, oil palm, coffee and African rice (Harlan, 1995). In addition to these indigenous crops, traders and travelers introduced exotic, imported, plant species that farmers selectively adapted and which now dominate African agriculture. Today, African farm households plant over half of all cropped area in imported plant species, principally maize, cassava, groundnuts, bananas, groundnuts, cocoa, other tubers and imported varieties of cotton (Table 1). By value, these imported species account for over two-thirds of gross agricultural output. Even more striking, the continent's 600 million head of livestock and 700 million head of poultry descend almost exclusively from imported species, with the lone exception of the guinea fowl (Diamond, 1998). Despite a virtual absence of indigenous domesticable livestock species and with a limited range of indigenous plants, African farmers have built up diverse agricultural systems based largely on imported plant and animal species. Much of this transformation has taken place without external assistance and in spite of the formidable constraints imposed by endemic trypanosomiasis which has largely prevented livestock rearing, animal traction and mixed cropping in the tropical zones.

In spite of these considerable historical achievements by African farmers, acute pessimism pervades much of the current dialogue on African agriculture. Comparisons of aggregate production performance across continents over the past forty years generate the now-familiar slippery slope alleging a deterioration in agricultural performance in Africa alone (Figure 1). Similarly, recent studies of world poverty single out Africa as the region of the world in which numbers of people malnourished and living in poverty have risen most rapidly in recent

Figure 1 -- Trends in Agricultural Production Per Capita by Region



Source: FAO.

decades (FAO, 1996; World Bank, 2001). These trends, coupled with political instability and a thicket of wars across the continent, have inspired the Economist magazine to label Africa as "The Hopeless Continent" (Economist, May 15, 2000). Even epidemiology has singled out Africa as the epicenter of a global AIDS crisis and malarial infestation (Bloom and Sachs, 1998). Discouragement spills over to the post-Cold War donor community, which has reduced funding for African agriculture by 40% since 1980 (Matthews, 1998; Atwood, 2000).

This bleak aggregate picture, however, contrasts with more promising indicators from individual case studies. In agriculture, micro-evidence from village studies documents a series of impressive achievements, what a recent review has called a collection of "small (and not so small) booms in production of food crops for the national and sub-national markets" (Wiggins, 2000). Nutritional data from individual children likewise suggest that Africa may be better off than South Asia, contradicting what the more pessimistic production-derived food availability figures imply (Svedberg, 1999; Osmani, 2000). Trends in the incidence chronic child malnutrition, as measured by stunting, suggest steady but gradual improvements over the past two decades (de Onis et al., 2000). Impact studies of agricultural research in Africa regularly demonstrate robust results. With median rates of return over 35%, investments in African agricultural research widely surpass those of most other, more fashionable investment opportunities (Evanson, forthcoming; Masters et al., 1998; Oehmke and Crawford, 1992).

Why the disconnect? Why are agricultural specialists so upbeat while donors and the public at large remain so defeatist? Resolution of these diverging perceptions remains of central importance for African policy makers given the critical role that agricultural growth will have to play in any program of broad-based poverty reduction in Africa.

This paper aims to contribute to these efforts by identifying major episodes of progress in African agriculture over the past seven millennia. As the first step in a much more extensive agenda[1], we have conducted a broad survey of experts on African agriculture, including African researchers and policymakers, donors, and Africanist specialists and researchers around the globe asking them to identify what they consider the most impressive moments in Africa's agricultural history. This paper describes the results of that survey, summarizing its methods as well as the collective wisdom of the respondents. By identifying instances in the past where important advances have occurred, this paper hopes to stimulate thinking about promising avenues for achieving similar success in the future.

[1] In order to establish a priority agenda for its work in Sub-Saharan Africa, IFPRI has initiated a major review of "Successes in African Agriculture." In addition to the present expert survey, this research program will undertake an extensive literature review coupled with in-depth examination of selected case studies of success in African agriculture. Details of this broader efforts are available at the IFPRI web site at http://www.ifpri.org/themes/syn04/syn04_activities.asp.

Table 1 -- Importance of Imported Plant Species in African* Agriculture, 1999

	Cultivated area		Production		
	million hectares	percent	MMT	value $ millions	value percent
Domesticated indigenous species					
sorghum and millet	41.6	27.2%	30.9	2,546	8.9%
cowpea	9.6	6.3%	3.1	976	3.4%
coffee	3.9	2.6%	14.1	2,395	8.4%
palm oil	3.9	2.5%	1.3	244	0.9%
yams	3.2	2.1%	4.9	730	2.5%
African rice**	3.8	2.5%	36.2	2,009	7.0%
other	3.5	2.3%	3.0	1,363	4.8%
subtotal	65.9	43.1%	90.5	$8,899.9	31.1%
Imported plant species					
maize	21.0	13.7%	26.9	2,540	8.9%
cassava	10.8	7.1%	92.5	2,221	7.8%
groundnuts	9.1	5.9%	7.8	1,083	3.8%
banana	5.0	3.3%	28.7	1,441	5.0%
cocoa	4.6	3.0%	2.0	389	1.4%
other tubers	4.6	3.0%	24.9	1,590	5.6%
cotton**	4.2	2.7%	3.5	725	2.5%
beans	4.2	2.7%	2.9	814	2.8%
Asian rice**	4.0	2.6%	7.0	1,050	3.7%
oilseeds	3.3	2.1%	0.9	153	0.5%
other crops	3.3	2.2%	1.7	551	1.9%
other cereals	2.7	1.8%	3.3	430	1.5%
others	10.3	6.7%	69.8	6,737	23.5%
subtotal	87.1	56.9%	271.9	$19,722.4	68.9%
Total	153.0	100.0%	362.5	$28,622.3	100.0%

* Africa refers to all of Sub-Saharan Africa, including the Republic of South Africa. It excludes the Northern African countries of Egypt, Tunisia, Lybia, Algeria and Morocco.

** Certain varieties of cotton and rice are indigenous to Africa. Since farmers plant virtually all cotton acreage with imported varieties, we have considered all cotton to be imported varieties. With rice, the partitioning assumes that African rice prevails in West Africa, Asian rice elsewhere.

Source: FAOSTAT.

2. SURVEY METHODS

a. The survey instrument

Our survey of expert opinion targeted a selected list of African and Africanist agricultural specialists. Based on their experience, we asked each to identify the instances they considered most important in advancing the state of African agriculture. To encourage the respondents to think broadly, we deliberately left the criteria for success, as well as time and geographic scope, unconfined. A one-page questionnaire posed the following single question: *"What do you consider the most successful instances of improved agricultural performance in Sub-Saharan Africa?"* It specified further that: *"You may list up to three nominations. Note that we place no boundaries on the time, scale, scope or content of these nominations other than that you consider them to be "successful" and that they relate to agriculture, including both livestock and crop agriculture."*

For each success story nominated, the survey form asked respondents to provide both their selection criteria as well as the factors they considered crucial in determining the success of each particular case. In addition, respondents supplied data on their institutional affiliation, place of work, nationality, functional responsibilities, disciplinary background and training.

b. The sample

We sent this nominating form to a broad spectrum of African agricultural specialists, together with a cover letter explaining IFPRI's objectives and interest in the outcome. To identify a target population of knowledgeable respondents, we drew on several key resources. First, we combined IFPRI's Africa mailing list with the institute's 2020 Network list of collaborators to produce a consolidated roster of African and Africanist stakeholders with active ongoing interest in agriculture and food policy in Africa. We supplemented these by drawing on directories published by the Special Program for African Agricultural Research (SPAAR), Agencies Supporting Agricultural Research in East and Central Africa (ASARECA), as well as a series of donor and NGO clearinghouses and directories of groups active in African agriculture. In total, these efforts yielded a roster of 1,116 total respondents.

Via email, post, and in some cases by hand, we delivered the nominating form to each of our identified respondents. We preferred email delivery where such coordinates were available because of its speed, ease and low cost of response – particularly in contrast with the long delays and high cost of postal mail out of Africa. Indeed, the respondents seemed to prefer email communications as well, as they yielded a response rate roughly triple that of the hard copy mailings. Overall, these efforts yielded an email roster of 428 professional colleagues. In addition, one of our investigators attended an ASARECA conference in Antananarivo, Madagascar in July 2000 where questionnaires were directly presented to the 76 conference

Table 2 -- Respondent* Characteristics (in percent)

A. Location			B. Institutional Affiliation	
	Nationality	Work Location		
Africa				
East	43	51	African national agricultural research organization	24
West	10	7	International agricultural research center	18
Southern	6	9	University or research institute	17
Central	5	4	Implementor (NGOs,project staff, private sector)	16
total	64	71	Donor	15
			African government	10
North America	15	20		100
Europe	15	7		
Asia	4	2		
Australia	2	0		
	100	100		

C. Function		D. Training	
technical research	32	agricultural economics	36
implementation/extension	24	plant sciences	35
policy research	22	animal sciences	9
policy maker	10	agricultural engineering	5
donor	9	management	3
information management	3	forestry and natural resource management	3
	100	general agriculture	2
		other sciences (nutrition, agrometeorology)	4
		other social sciences (sociology, political science)	3
			100

* The total sample includes 118 respondents.

Source: IFPRI Expert Survey.

participants from East and Central Africa. For the remaining 612 respondents, we posted the survey form and cover letter to their mailing addresses around the globe. Out of the 1,116 specialists targeted, 55% received their questionnaire by mail, 38% by email and 7% by hand delivery.

This three-pronged data collection effort elicited a total of 118 responses, an overall response rate of 10.6%. The rate varied considerably, however, by source. As expected, the direct approach at the ASARECA conference generated the highest return rate, 39 responses out of 76 questionnaires distributed for a response rate of 51%. Email queries induced 52 responses out of 428 contacts, yielding a response rate of 12%. The postal mailing produced the lowest response, 17 in total (11 by fax and 6 by mail), for a response rate of 4.4%.

Of the 118 total respondents, roughly two-thirds are African, a majority of these coming from East Africa, while over 70% of respondents live and work in Africa (Table 2). The high number of East African nationals and residents in the sample stems from our attendance of the ASARECA conference, from the prevalence of international organizations based in Nairobi, Kampala and Addis Ababa, and from apparently superior phone, fax and email connections to that region. Functionally, about one-third of the respondents conduct technical agricultural research, while a further one-fourth implement promotional activities, one-fourth conduct policy

research and the remaining 20% work for African or donor governments. Among institutional affiliations, African national agricultural research organizations (NARs) predominated, accounting for about one-fourth of all respondents. International agricultural research institutes, universities, implementers and donors followed, with roughly comparable representation of 15% to 18% each, while the remaining 10% worked within African governments, primarily in ministries of agriculture. Across disciplinary backgrounds, agricultural economists and plant scientists accounted for about one-third each of total respondents, with the remaining one-third scattered across other technical agricultural disciplines and social sciences.

c. Potential sample biases

Our sample includes a concentration of African professionals as well as a mix of nationalities, disciplines and functional roles. Still, the predominance of respondents from East Africa and from technical agricultural research institutes invites concern about possible locational, functional and disciplinary biases in the respondent pool. For this reason, the ensuing analysis will test formally for these biases, and where they exist, will disaggregate results by region, discipline or function, as appropriate.

After taking appropriate cognizance of these potential biases, we believe the judgment of these professionals offer important information to policy makers. We were impressed by the enthusiasm, the detailed suggestions, comments and references provided by many of our respondents. One went so far as to mail us a 30-page response from Khartoum! We are indeed grateful to the 118 busy professionals who took time from their pressing obligations to give us the benefit of their collective wisdom, which the following sections will summarize.

3. SUCCESSES AND CRITERIA

a. Successes identified

Because many among our panel of experts identified multiple successes in African agriculture, their responses generated a total of 253 individual nominations. To preserve the rich detail and diversity contributed by our group of experts, Annex Table 1 provides a complete listing of all the success nominations received. Amid considerable diversity, several key generalizations did nonetheless emerge.

Commodity-specific successes

A solid majority of responses, slightly over 60%, identified successes linked to specific commodities (Table 3). Commonly they focused further on very specific activities, locations or time periods. The most common single response, for example, concerned biological control of the cassava mealybug during the 1970's and 1980's, associating both a specific commodity and a very specific intervention. Likewise, the breeding and diffusion of high-yielding varieties of maize in East and Southern Africa attracted considerable attention. These, too, often proved time-specific, with one case referring to Kenya from 1963 to 1973 and another Malawi from 1987 to 1995. According to another respondent, the successful introduction of coffee, from the 1930's to the 1960's, propelled the Kilamanjaro region of Tanzania to become the richest region in East Africa by the mid-1950's. Among a broad panoply of commodity-specific nominations, maize featured most commonly, followed by cassava, horticulture and livestock.

While maize and cassava emerged prominently across many countries and regions, other commodities successes proved more localized (Table 4). Given regional differences in climate, soil, rainfall and cropping systems, this local specificity comes as no surprise. In East Africa, horticultural exports, dairy production and bananas garnered most attention, while in West Africa cotton, cocoa and recent advances in rice production emerged most consistently. In Southern Africa, the composition of commodity-specific nominations proved more diverse; beyond the ubiquitous maize, citations included horticulture, cotton, livestock, wool production and aquaculture.

Activity-specific successes

Outside of the commodity successes, remaining nominations split roughly in half, with about 20% each highlighting either specific activities or the building of key agricultural institutions (Table 3). Among the activity-specific nominations, improved techniques for soil fertility enhancement received the most prominent mention. These efforts include work with improved fallows, often in association with nitrogen-fixing trees, crop rotations incorporating legumes, and application of locally available rock phosphate as mineral supplements. Similar

nominations from West Africa focused on alley cropping and crop rotations including legumes, while several from Southern Africa centered on related dryland soil and water management techniques commonly grouped under the label of conservation farming.

Policy reforms – in either specific agricultural markets or in enabling macro policy environment – also emerged prominently among the activity-specific nominations. Devaluation of the CFA franc in francophone West Africa in the mid-1990's attracted the greatest interest. Respondents widely credited the devaluation with stimulating the export of livestock, cotton and horticultural products from the region. A series of food policy reforms in East and Southern Africa likewise prompted frequent mention as vehicles for stimulating competition in milling and food marketing, thereby ensuring lower prices and improved food quality to low-income consumers throughout the region. Similar rice market liberalization efforts in Mali, from the mid-1980's, introduced marked increases in competition among millers and traders which, in turn, significantly boosting farmer incentives and production. A number of respondents highlighted the important impact of irrigation investments across the continent, ranging from large-scale gravity-fed perimeters like the Gezira Scheme in Sudan to current small-scale treadle-pump irrigation efforts in Niger.

Institution building

Institution-building successes focused on the substantial investments by donors and African governments during the 1960's and 1970's in African national agricultural research organizations (NARs). Farmer organizations, spontaneous and induced, likewise attracted interest as vehicles for common property management, technology development and testing, for the design, financing and management of rural infrastructure, and for the marketing of key production inputs or farm outputs. Commenting on a recent visit to one West African country, a respondent reported, "I was awed by what I saw. The farmer groups there are a powerful force today."

Interest in the development of market institutions and in basic human skills outside of agriculture closely mirror the core of activity-specific enthusiasm for policy reforms. As one respondent noted, "I am particularly impressed by the important contribution that people in Ministries of Finance have played in redressing the macroeconomic problems faced by many African countries in the 1980's, balancing the pressures of the World Bank and IMF on one hand and domestic political pressures on the other. Their contribution to improved macroeconomic performance (and hence agricultural performance) that most African countries enjoy compared to the 1980's has been under-appreciated."

Further interest in market institutions reflects the findings of recent work on market behavior in Africa which underlines the important role of institutions in promoting trust, protecting property rights, reducing transaction costs, and enabling exchange critical to market efficiency (Fafchamps and Minten, 1999; Gabre-Madhin, 2000). Our respondents, like many agricultural specialists, recognize that the further development of key agricultural support institutions will prove critical to the expansion of production possibilities and to improved agricultural performance with a given set of technology and endowments (Bardhan, 1989; North, 1990).

Table 3. Agricultural Successes Identified

Category	Successes Identified		
	Total	Africa-wide	Region-specific
Commodity-specific			
maize	10.3%	11.1%	10.0%
cassava	6.7%	15.3%	3.3%
horticulture	6.6%	1.4%	8.6%
livestock	6.2%	9.7%	4.8%
cotton	4.5%	1.4%	5.7%
coffee	4.3%	5.6%	3.8%
dairy	3.4%	0.0%	4.8%
rice	3.3%	5.6%	2.4%
cocoa	2.5%	2.8%	2.4%
banana	2.5%	1.4%	2.9%
beans	1.8%	1.4%	1.9%
other	9.5%	6.9%	10.5%
subtotal	***61.6%***	***62.5%***	***61.2%***
Activity-specific			
soil fertility enhancement*	7.1%	5.6%	7.7%
policy reform			
agricultural markets	2.0%	0.0%	2.7%
macro policy	1.6%	0.0%	2.2%
irrigation development	2.4%	1.4%	2.7%
specific technology development**	1.6%	1.4%	1.6%
other	6.7%	6.9%	6.6%
subtotal	***21.2%***	***15.3%***	***23.5%***
Institution-building			
agricultural research	5.5%	12.5%	2.7%
farmer organizations	3.1%	1.4%	3.8%
market institutions	2.4%	1.4%	2.7%
human capacity building***	1.6%	5.6%	0.0%
other institutions	3.5%	1.4%	4.4%
subtotal	***16.1%***	***22.2%***	***13.7%***
Countries			
Ethiopia, 1990's	0.4%		0.5%
Ghana, 1990's	0.4%		0.5%
Ivory Coast, 1960's and 1970's	0.4%		0.5%
subtotal	***1.2%***		***1.6%***
Total			
Share	***100.0%***	***100.0%***	***100.0%***
Number of nominations	***253***	***71***	***182***

* Includes improved fallows, crop rotations, conservation farming.
** Biotechnology applications, vaccines.
*** Finance, management, business.

Source: IFPRI Expert Survey.

Table 4 -- Regional Differences in Identified Commodity Successes*

Commodity	West	Central	East	Southern	General	Total
maize	6%	17%	***16%***	***28%***	***18%***	17%
horticulture	6%	0%	***21%***	***13%***	2%	11%
cassava	0%	17%	9%	3%	***24%***	10%
livestock	9%	17%	5%	9%	***16%***	10%
cotton	***24%***	17%	0%	9%	2%	8%
coffee	6%	0%	9%	3%	9%	7%
dairy	3%	17%	***13%***	3%	0%	6%
rice	***9%***	0%	2%	3%	9%	5%
banana	0%	17%	***9%***	0%	2%	4%
cocoa	***15%***	0%	0%	0%	4%	4%
beans	6%	0%	2%	3%	2%	3%
tubers	3%	0%	5%	0%	4%	3%
tea	0%	0%	5%	0%	0%	2%
wool	0%	0%	0%	6%	0%	1%
aquaculture	0%	0%	0%	6%	0%	1%
wheat	0%	0%	0%	3%	0%	1%
tobacco	0%	0%	0%	3%	0%	1%
cowpeas	3%	0%	0%	0%	0%	1%
oil palm	3%	0%	0%	0%	0%	1%
onion	3%	0%	0%	0%	0%	1%
other	6%	0%	4%	6%	7%	5%
total	100%	100%	100%	100%	100%	100%
Number of nomination	34	6	56	32	45	173
Share of total	20%	3%	32%	18%	26%	100%

* ***Bold italics*** highlight key differences across regions.

Source: IFPRI Expert Survey.

Country-specific successes

Country-specific aggregate success stories inspired little enthusiasm, attracting only about 1% of all nominations. These included Ivory Coast's agriculturally powered post-independence economic growth, the so-called "Ivorian miracle" of the 1960's and 1970's, as well as more recent surges in Ethiopia and Ghana during the second half of the 1990's.

This disparity between widespread commodity successes and a paucity of aggregate country nominations mirrors the dichotomy alluded to earlier between the widespread case-study optimism and the pervasive aggregate pessimism. One respondent suggests a plausible explanation for this apparent divergence by noting that, "The real trick does not seem to be the isolated success stories but a pattern of building on these in order to generate other commodity success stories and a general pattern of sustained growth and development at a country level."

Evidently, few countries have accorded agriculture the priority necessary, in either policy debates or investment allocations, to sustain agricultural support institutions capable of generating a steady stream innovations and growth. In the presence of exceptional rates of return[2] as well as exceptional need, this persistent underinvestment in frontline agricultural research and related support institutions appears puzzling at first. But after spending some time in African ministries of finance, it quickly becomes clear that narrow tax bases coupled with enormous debt loads and donor-imposed priorities on social spending leave little room for maneuver or debate over the relative role of productive investments in agriculture. An opening up of these budget debates will require a renewed commitment to agriculture by both African governments as well as donors.

Africa-wide successes

While most successes proved location-specific, a significant minority -- of about one-quarter overall -- applied Africa-wide. Given the much broader impact of such general successes, these merit particular scrutiny (see column 2, Table 3). A string of cassava-related successes – from it's introduction by traders and farmers in the 16th century, to the defeat of the cassava mosaic virus in the 1930's and again in the 1980's, and biological control of the mealybug in 1980's – benefited literally millions of farmers in across a wide swath of Africa. Likewise, the institution-building investments in agricultural research systems rise emerge prominently as the second most frequently cited general success in improving agricultural systems across the continent.

b. Regional and disciplinary biases

Not surprisingly, respondents generally report about what they know best. Both nationality and work location influence the location of the successes identified. Consequently, all respondents born or working in a particular region cite more successes in that region than would an average outsider (Table 5).

Yet East Africans and the professionals resident there, who account for 40% and 50% of our sample, respectively, turn out to be the least insular and most likely to cite successes from outside their region. About 40% of their nominations centered on general, Africa-wide successes, the highest share of any group. As a result, the majority of their nominations were either general or specific to other regions than their own.

Moreover, evidence from other respondents suggests that part of the higher concentration of East Africa nominations may stem from genuine perceptions of superior agricultural performance there. Indeed, respondents from North America, Australia, and Asia all cited more successes in East Africa than in any other region. Conversely, Europeans proved most likely to nominate successes in West Africa. Ultimately, slightly less than one-third (32%) of the successes cited occurred in East Africa even though over half (51%) of our respondents work in the East Africa region (Table 5).

[2] See Evanson (forthcoming); Masters et al. (1998); Oehkme and Crawford (1993).

Table 5 -- Regional Biases Among Respondents

	Location of the Successes Nominated					Total nominations	
	West Africa	Central Africa	East Africa	Southern Africa	General	percent	number
Nationality of expert making the nomination							
Africa							
West	***64%***	8%	4%	0%	24%	100%	25
Central	21%	***50%***	0%	14%	14%	100%	14
East	3%	3%	***46%***	11%	***38%***	100%	109
Southern	0%	0%	0%	***94%***	6%	100%	17
Europe	30%	0%	27%	21%	21%	100%	33
North America	32%	0%	36%	23%	9%	100%	44
Asia	27%	0%	36%	18%	18%	100%	11
Australia	0%	0%	50%	0%	50%	100%	4
							257
Work region of expert making the nomination							
Africa							
West	***63%***	13%	0%	0%	25%	100%	16
Central	10%	***50%***	0%	20%	20%	100%	10
East	9%	4%	***42%***	7%	***38%***	100%	131
Southern	0%	0%	0%	***95%***	5%	100%	21
Europe	32%	0%	16%	37%	16%	100%	19
North America	34%	0%	39%	19%	8%	100%	62
Asia	40%	0%	40%	20%	0%	100%	5
							264
Total nominations*	52	12	84	51	65	264	
	20%	5%	32%	19%	25%	100%	

* Because several respondents cited multiple regions, most commonly East and Southern Africa, total locations exceeds the total of 253 nominations slightly.

Source: IFPRI Expert Survey.

Disciplinary and functional biases likewise emerge from our results. Not surprisingly, our respondents proved most well-versed about activities within their own professional purview. Technical agricultural scientists cite institution-building successes in agricultural research more frequently than do other respondents. Social scientists cite policy reforms and institutional development among farmer organizations and market institutions more frequently than other respondents. Project implementers, extension staff, NGO personnel and other operational staff are least likely to cite commodity-specific successes and more likely than average to designate specific activities such as soil fertility enhancement, irrigation development and the building up of agricultural research institutions. (Table 6). Together, these distinctions suggest that it will be useful to disaggregate many ensuing results regionally or by respondent category.

Table 6 -- Exploring Possible Disciplinary Biases

Successes Identified	Respondent Categories* Technical researchers	Social Scientists	Implementors	Government /donors	Total
Commodity-specific					
food crops	34%	31%	27%	29%	31%
cash crops	19%	20%	15%	21%	19%
livestock/dairy	***18%***	11%	8%	6%	11%
subtotal	70%	63%	51%	56%	61%
Activity-specific					
soil fertility enhancement	4%	6%	***17%***	2%	7%
irrigation development	1%	0%	3%	***6%***	2%
market/policy reform	0%	***11%***	0%	4%	4%
other	9%	2%	8%	***15%***	8%
subtotal	15%	19%	29%	27%	22%
Institution-building					
agricultural research	***11%***	2%	***7%***	2%	6%
farmer organizations	0%	***6%***	0%	***8%***	3%
market institutions	1%	***5%***	2%	2%	2%
other institutions	3%	6%	8%	4%	5%
subtotal	15%	19%	17%	15%	16%
Countries	0%	0%	3%	2%	1%
Total	100%	100%	100%	100%	100%
N	74	64	59	52	249

Bold italics indicate above-average representation.
Underlining indicates below average representation.
* Differences across respondent categories are significant at the 1% level.

Source: IFPRI Expert Survey.

c. Selection criteria

What implicit criteria define "success" in African agriculture? Our respondents, like much of the literature, overwhelmingly focus on production growth. Roughly 40% of the cases cited involve significant increases in agricultural output, while another 20% cite corollary efficiency concerns about increased farmer incomes and foreign exchange earnings (Table 7). Given the public prominence accorded to gloomy aggregate production trends, it is not surprising that professional preoccupation with reversing this falling per capita production pervades the agricultural community.

Equity concerns feature in a further 20% of the success nominations. Respondents express these concerns principally in terms of helping small farmers, women and other vulnerable groups, or improving food security. In the present environment -- where poverty alleviation has, as in the 1970's, become a central focus of donor efforts; where the IMF and World Bank have transformed structural adjustment programs into poverty reduction programs

Table 7 -- Respondents' Criteria for Success

Criteria	Respondent Category*				
	Total	Technical research	Social or policy research	Implementor	Govt
Efficiency					
Farmer gains					
production increase	39%				
farmer income increase	14%				
improved nutrition	2%				
risk reduction	1%				
Government					
foreign exchange earnings increase	5%				
increased tax revenues	1%				
high return on public investment	1%				
subtotal	63%	70%	59%	54%	70%
Equity					
help small farmers	9%				
food security	4%				
helps other vulnerable groups (women, poor)	6%				
subtotal	20%	15%	21%	23%	21%
Sustainability					
Farm-level					
improves soil fertility	8%				
environmentally sustainable intervention	5%				
Agricultural system					
train people	2%				
improve markets	2%				
improve other institutions (land tenure, credit, communications)	2%				
subtotal	18%	15%	21%	23%	10%
Total criteria cited	100%	100%	100%	100%	100%

* Differences between groups are not statistically significant.

Source: IFPRI Expert Survey.

and morphed policy framework papers into poverty reduction strategy papers -- these equity concerns will likely increase. Indeed, our respondents have likely understated the importance of agriculture for poverty alleviation in Africa. While their stated equity concerns center on directing income gains to poor farmers, agriculture's broader role in determining food prices for the urban and rural non-farm poor substantially increases the importance of agriculture as a tool for poverty alleviation. Production gains --regardless of whether they come from large or small farms—can contribute to poverty alleviation via falling real prices for food staples. Viewed from the perspective of poor African consumers, agricultural growth itself becomes a powerful instrument for poverty reduction.

Sustainability of production gains likewise elicited considerable attention from our respondents, garnering 18% of the rationales they cited. This concern mirrors recent increases in research attention to soil fertility and sustainability of evolving African agricultural systems (Sanchez et al. 1997; Pretty, 1995; Cleaver and Schreiber, 1994). In the presence of increasing population density, where shifting cultivation becomes more difficult and fallows periods available for soil reconstitution become shorter, maintenance of soil fertility will increasingly

become a key pillar in building sustainable systems for future agricultural growth. For this reason, some agricultural specialists assert that soil fertility investments in Africa today will prove functionally equivalent to the HYV germplasm that drove the Green Revolution in Asia. (Borlaug and Doswell, 1994; Conway, 1997; Sanchez and Jama, 2000).

4. CLOSER LOOK AT MAJOR AGRICULTURAL SUCCESSES

This section describes the broad features of a dozen of the successes stories cited by our respondents. Table 8 summarizes the key components of each, while the following discussion embellishes this summary with a more detailed account of the activities and outcomes that constitute each case. Though not exhaustive, the roster offers an illustrative cross-section of commodities, activities, regions and time periods.

a. Africa wide commodity successes

Cassava: introduction and modern disease fighting research.

After its introduction by Portuguese traders in the mid-1500s, cassava production spread rapidly from the Congo trading stations across Central Africa (Jones, 1957). Farmers and tribal leaders disseminated the crop in rapid though patchwork fashion. They valued its drought tolerance, its known resistance to locusts, low labor requirements and its ability to survive in low-fertility soils. In local farming systems, it supplanted yams in some locations and cereals in others. In West Africa, cassava production spread more slowly until after 1780 when the settlement of a small colony of freed Brazilian slaves stimulated more rapid diffusion through their regional trading networks and their simultaneous introduction of processing technology from South America. Its widespread adoption in the interior of West Africa accompanied the arrival of large-scale labor movements from coastal to interior zones after 1900. Introduced into East Africa only after 1800, cassava spread west into the interior from Zanzibar and Mozambique. It remained an unimportant crop until after 1850 when Arab and European traders promoted it as a seasonal food security and famine prevention crop (Jones, 1959). Throughout the continent, a network of traders, farmers and tribal leaders successfully introduced and disseminated cassava across most of its present range well before European penetration of the interior. In doing so, they successfully established a new staple food serving hundreds of millions of African consumers and providing an on-site food security reserve for many of the continent's poor.

Cassava's first serious threat in Africa emerged in the 1920's and 1930's when outbreaks of the cassava mosaic virus erupted across the continent, threatening this increasingly important food security crop (Jones, 1959). Spread by a white fly, the new virulent strains of cassava mosaic virus spread rapidly with severe outbreaks occurring in Ghana, Nigeria, Cameroon, Central African Republic, Tanganyika and Madagascar. Farmers responded immediately by replacing affected plants with cuttings from unaffected varieties. This led to a large turnover in varieties as well as the complete elimination of many. In response to this serious threat, colonial agricultural research stations in Tanzania, Kenya, Madagascar and Ghana introduced cassava

breeding into their programs for the first time (Cours et al., 1997; IITA, 1992). In some instances, as in Madagascar, the presence of large settler export plantations provided further impetus for action. Successful breeding at several of these stations led to the development of a series of largely disease-resistant hybrids. Requiring about 10 years of intensive research, the new resistant varieties, once developed, spread rapidly, largely replacing the affected "local" varieties. As its enduring legacy, this widespread scare engraved cassava for the first time onto the agenda of Africa's colonial agricultural research stations.

Renewed threats emerged in the early 1970s, following a devastating pair of pest infestations. Accidentally imported from their native South America, the cassava mealy bug emerged first in Zaire in 1973, while the cassava green mite surfaced on imported farm machinery coming into Uganda in 1971. In the absence of their natural predators, both spread rapidly across the continent. The mealy bug, the more voracious of the two, caused crop losses of 80% as it ate its way across the continent at over 300 kilometers per year. By the early 1980s, the mealybug had infested the entire African cassava belt where it threatened the principal food source of over 200 million Africans (Herren and Neuenschwander, 1991).

The seriousness of this threat inspired a concerted decade of collaborative work by international and national research institutes leading to a widely heralded biological response. In 1981, after a year of intensive, focused exploration, researchers at CIAT and the Commonwealth Agricultural Bureau's International Institute of Biological Control (IIBC) identified a natural predator of the mealy bug in South America, a parasitic wasp. The International Institute for Tropical Agriculture (IITA), with strong funding primarily from the International Fund for Agricultural Development (IFAD) and other donors rapidly mounted a mass rearing and distribution program in collaboration with African NARs. First released in 1981, the predator wasp had, by 1988, largely controlled the mealy bug threat throughout Africa. Conservative estimates place the value of production saved at over $2.2 billion against a program cost of $15 million, generating an eye-popping benefit cost ratio of 149 (Norgaard, 1988).

Inspired by this highly successful biological control of the cassava mealybug, researchers at IITA and CIAT spurred their attempts to find biological solutions for the lingering but deadly cassava green mite (Yaninek and Schulthess, 1993). Though work proceeded more slowly than with the mealybug, researchers ultimately identified a suitable predator mite which they released in a dozen cites across the continent beginning in 1993. A ferocious predator, it reduces the cassava green mite to a dried up shell in minutes. Widely crediting with preserving the cassava crop in 20 African countries, the predator mite has been popularly dubbed as "The bug who saved Africa" (Washington Post, May 26, 1997)

Maize: introduction of modern HYVs.

Following introduction by the Portuguese along the periphery of the African coast beginning in the 1500's, maize penetrated the interior of the continent at widely varying rates (Miracle, 1966). Incentives for maize production received a major boost in the early 1900's, in East Africa from expanding export sales to England and in Southern Africa from the steadily expanding need to feed growing populations of mineworkers (Byerlee and Eicher, 1997; Wood et al., 1990). By the 1950's, maize had become the third leading source of calories on the

continent and the predominant food crop of white settlers East and Southern Africa (Miracle, 1966).

Modern maize breeding programs began first in Southern Rhodesia (now Zimbabwe) and Kenya to support large white commercial farmers. In 1960, after 28 years of research, the Southern Rhodesian agricultural service produced the first major breakthrough in maize technology in Africa with the release of the now-famous SR52 hybrid (Eicher, 1995). It spread rapidly among commercial white farmers in Rhodesia and Zambia, achieving over 90% adoption within a decade. At independence in 1980, a reorientation of its research program to the needs of small farmers, together with credit and extension programs and a well-functioning seed supply industry produced a "second maize revolution" as small farmer adoption surged beginning in the early 1980's (Eicher, 1995). Kenya's agricultural research system achieved similar successes with the release of improved HYV's in the mid-1960's. Large commercial farmers adopted the new high-yielding varieties rapidly as did smallholders subsequently. In favorable zones, 95% of both large and small farmers adopted the HYVs (Gerhart, 1975; Byerlee and Eicher, 1997).

Following these two regional leaders, national research programs in other parts of East and Southern Africa have produced improved technologies, in the mid-1970s in Zambia and in the late 1980's in Malawi (Wood et al, 1990; Heisey and Smale, 1995). To support these national programs, CIMMYT established regional maize programs in East and Southern Africa beginning in the late 1970's.

In West Africa, maize research has focused on small farmers from the outset, resulting in a very different composition of new technology. While the commercial-farmer-dominated programs of East and Southern Africa have historically focused on hybrids, which require annual supply of new seeds, West African researchers have emphasized improved yield and nutritional content of open-pollinating varieties of maize. Production gains have proven geographically spottier here, though in the mid-1980's Ghana achieved nearly 50% adoption rates for newly released high-yielding open pollinating maize varieties. Nigeria and Senegal have likewise witnessed rapid adoption of new open pollinating varieties (Byerlee, 1994). Though starting from a lower base, West Africa has achieved the fastest rate of maize production growth in Africa, with increases of 4.5% per year between 1975 and 1995 (Byerlee and Eicher, 1997).

Though production gains have fluctuated across regions and over time, farmers overall in Sub-Saharan Africa currently plant slightly over one-third of maize area in improved varieties (Morris, 1998). Under farmer conditions, these improved varieties have typically contributed to yield gains of 40% in hybrids and 15% to 25% in open-pollinating varieties. The most prominent successes have emerged from the epicenters of African maize production, Zimbabwe and Kenya. In Kenya, from 1963-73, the rapid adoption of hybrid maize varieties doubled national maize production and generated national production gains valued at $1 billion per year (Gerhart, 1975). In Zimbabwe, following the commercial farmer spurt in the 1960's, smallholders doubled maize production in the short six-year period from 1980 to 1986, on the heels of subsidized credit and input supply programs tailored to them (Eicher, 1995). This experience, coupled with widespread maize marketing reforms in East and Southern Africa during the 1980's and 1990's has underscored the importance of input supplies (of fertilizer and

seed) as well as assured markets and adequate price incentives in maintaining continued upward momentum in maize production in the future (Byerlee and Eicher, 1997).

Rinderpest vaccine.

Rinderpest, a devastating livestock disease, was unwittingly imported from Asia to tropical Africa by Italian army forces in 1889. Lacking exposure and resistance to the virulent, exotic virus, African herds rapidly succumbed. The ensuing rinderpest epidemic of 1890 ravaged the continent, killing over 5 million cattle south of the Zambezi River, in spite of massive investments in cordon fences and other preventative measures. In short order, the disease killed an estimated 95% of Africa's cattle (Reader, 1997; Mack, 1970). Thereafter, rinderpest remained the continent's most deadly threat to livestock and to many wild animals as well, diverting veterinary resources from other animal health and improvement activities.

To address this widespread threat, the Organization of African Unity established an Inter-African Bureau on Animal Resources (IBAR) to coordinate an all-out international effort to control rinderpest. Beginning in 1986, this budding alliance involved national governments, their veterinary services, international centers and donors as a coalition of 35 countries launched the Pan Africa Rinderpest Campaign (PARC). Their concerted efforts resulted in the development of a tissue culture attenuated vaccine for the control and eradication of rinderpest (Plowright and Ferris, 1962; Provost, 1982). Following development of the vaccine, government and private veterinary services across the continent distributed the vaccine (Scott, 1985; Wamwayi et al, 1992).

Through these efforts, they have succeeded in controlling rinderpest all across African except where civil unrest prevents effective vaccination campaigns. Recent assessments evaluate income gains on the order of $50 million for livestock producers in 10 of the 35 countries evaluated. The production gains have generated $1.80 in net income for every dollar invested in the vaccination program (Tambi et al., 1999). In 1999, in recognition of his important contributions, Dr. Walter Plowright became the first veterinarian to receive the World Food Prize for development of the first effective rinderpest vaccine.

b. Regional commodity successes

Bananas in the Central Highlands.

Farmer ingenuity in the adaptive breeding of bananas launched an extraordinary agricultural and demographic revolution in the Central African Highlands. Beginning about 1300 A.D., after eight hundred years of intensive on-farm breeding, the wide-spread emergence of highly productive banana gardens and plantations triggered a striking economic and demographic transformation that laid the foundation for the subsequent political rise of the Buganda kingdom (Reader, 1997; Schoenbrun, 1993).

These extraordinary changes began when Arab traders first introduced bananas from South-East Asia to the coast of East Africa sometime after 500 B.C (Wrigley, 1989; Reader, 1997). From there, they transited slowly inland arriving in the central African highlands about

500 A.D. where they found an almost ideal climate in Uganda, Rwanda, Burundi and eastern Congo. Farmers in the region experimented intensively with bananas, because of the new crop's lower labor requirements, high calorie yields per hectare and favorable effects on soil erosion. Through assiduous selection of cultivars, farmers bred a wide range of cultivars suitable for human consumption. Linguistic, archeological and palynological evidence suggests that intensive cultivation of banana plantations began around 1300 A.D. stimulating a population explosion in the region that remains still today one of the most densely settled regions of Africa (Schoenbrun, 1993).

By the time bananas became a subject of interest to western plant geneticists, in the mid-twentieth century, Ugandan farmers were cultivating 60 different cultivars, the largest pool of genetic diversity anywhere in the world (de Langhe et al., 1996; Reader, 1997). International centers such as INIBAP and IITA as well as concerned regional NARs began serious breeding programs in the 1980's in response to the banana's established importance as a principal food staple, growing threats from pests and fungal disease, and the slowness of farmer-dependent selection of new varieties. Because most edible bananas are seedless, they must be reproduced by vegetative propagation, severely limiting the prospects for genetic evolution. Given this constraint, most experts marvel at the rapidity with which African farmers achieved such genetic diversity (Simmonds, 1959; McMaster, 1962).

Modern tissue culture offers prospects for rapid advances in both yield and resistance to major pests and disease. Moreover, it enables rapid and sterile multiplication of pathogen-free planting material. Recent efforts by the Kenya Agricultural Research Institute (KARI), in conjunction with a local private biotechnology company, have begun to produce in vitro banana plants commercially. Even at full commercial costing, the tissue culture plants roughly double both yield and income under farmer conditions (Qaim, 1999). As one of our Kenyan survey respondents attests, "Small scale and large-scale farmers are currently benefiting from tissue culture banana technology," a solution which responds to the former, "desperate situation of lack of clean planting material." Together, farmers and scientists have developed a highly suitable food security crop that currently accounts for over one-fourth of caloric consumption in countries such as Rwanda and Uganda (FAOSTAT).

Cotton production in Francophone West Africa.

Successful efforts at cotton promotion over the past four decades in French West Africa have built on a long tradition of farmer experience with cotton cultivation in the region (Roberts, 1996). Since independence in the 1960's, cotton production and exports have both grown rapidly. At the same time, cotton promotion has formed a central pillar of African and French government efforts to support rural development in the arid zones of francophone West Africa.[3]

[3] The large and sustained government contributions to institutions promoting cotton production have invited controversy. Some observers charge that large hidden state subsidies prop up the sytem. Others maintain that, conversely, the system implicitly taxes farmers. Still others suggest that the cotton companies subsidize general rural development efforts through their extension support, residual impact of animal traction and fertilizer on food crops and through the literacy, women's and other general development programs run by many of the cotton agencies. For an introduction to these debates, see Coton et Développement (1998)

To ensure scientific and commercial support for these efforts, the French government established two key institutions whose descendants continue today to promote cotton cultivation in French West and Central Africa. In 1946, they founded a publicly funded cotton research organization, the Institut de Recherche du Coton et des Textiles Exotiques (IRCT) to expand cotton research undertaken since 1901 by earlier colonial institutions (Dequecker, 1999). To handle input supply, output marketing, processing and export, they established a mixed public-private commercial firm, the Compagnie Francaise pour le Developpement des Fibres Textiles (CFDT), in 1949 (Courtant, 1991). At independence, in the 1960's, the CFDT underwent a series of transformations in each of the newly independent African states. All countries, except Benin, established new mixed private-public commercial companies, with CFDT as a major shareholder. The fully integrated model, with production, processing and marketing support provided by a single company, continues in Mali, Ivory Coast, Cameroon, Central African Republic and Senegal. Several countries, however, have opted to split the farmer extension and input supply functions to separate rural development agencies, as in Burkina Faso, Togo and Chad. All countries continue to operate government-sponsored price stabilization funds, which allow purchasers to announce guaranteed farmer price before planting (Courtant, 1991).

This vertically coordinated package of support includes both input supply as well as guaranteed markets for output.[4] Provision of improved inputs such as new cotton varieties, fertilizer, insecticides, animal traction equipment and extension support have sustained generally rising output and yields. Between 1960 to 1999, cotton yields quadrupled as the use of fertilizer has increased to over 75% in the major producing countries and use of animal traction equipment has risen from near zero to 50% in Burkina Faso and Ivory Coast and to 90% in Mali and Cameroon (Follin and Deat, 1999). In addition to rising cotton earnings, farmers have benefited indirectly from important residual effects of cotton fertilizer and animal traction on cereal production (Giraudy, 1999).

As a result of this carefully coordinated, state-sponsored package of support, cotton production and exports have grown rapidly in francophone Africa, at a compound annual rate of about 6.5% per year over the past forty years (Béroud, 1999). Growth has proven most robust in the four West African countries of Mali, Benin, Burkina Faso and Ivory Coast which, together, produce 70% of total cotton production in francophone Africa (Béroud, 1999). Though momentum stalled in the late 1980's and through the mid-1990's, devaluation of the CFA franc in 1994, coupled with a rapid rise in world prices, effectively resuscitated farmer incentives (Tefft, 2000). Consequently, production in francophone Africa has nearly doubled since 1994, growing from 500,000 to 980,000 tons (Béroud, 1999). Over the past forty years, francophone Africa's share in world exports has grown from near zero to 16%, making them the world's third largest cotton exporting block after the USA and the former USSR (Bocchino, 1999). Cotton export earnings currently amount to $100 to $160 million per year in each of the principal West African exporting countries of Mali, Benin, Burkina Faso and Ivory Coast (FAOSTAT), while cotton production and its promotional institutions remain the centerpiece of rural developments in much of francophone West Africa.

[4] See Lele, van de Walle and Gbetiboijo (1990) for a good overview of the cotton support system in francophone West Africa compared to institutional systems prevailing in anglophone African countries.

Horticulture and cut flower exports from Kenya.

Beginning in 1957, private traders in Kenya began to export small quantities of off-season vegetables as well as tropical and temperate fruits to the United Kingdom and the Middle East. These initial forays abroad built on pre-existing production sources geared to the domestic market for quality vegetables in the local tourist trade (Jaffee, 1995). Because of limited freight capacity and irrigation facilities, this trade remained small throughout the 1960's. But from the early 1970's onward, the high-value export trade expanded steadily as a result of growing demand in Europe, improved technologies and marketing systems for fresh vegetable distribution there, and substantial increases in air-freight space from Nairobi to Europe, a byproduct of Kenya's booming tourist industry. In response, growing private investment in irrigation facilities enabled Kenyan producers to emerge as a leading supplier of high-quality green beans, sweet peppers, and zucchini. Dominated by ethnic South Asians, the Kenyan exporters rapidly targeted European immigrant markets for okra, chilies and other Asian vegetables and spices. Kenya has outperformed other Sub-Saharan African countries in this market by virtue of its broad product range and ability to provide year-round, rather than simply seasonal, supplies (Jaffee and Gordon, 1993).

During the 1980's and 1990's, this export trade has shifted as Kenya lost its market for temperate vegetables such as sweet peppers and zucchini to lower-cost suppliers in the Mediterranean. But exporters simultaneously expanded trade in French beans, Asian vegetables, cut flowers and tropical fruits. To ensure consistent quality and timely supply, many exporters developed contract-farming arrangements with smallholders, who supply about 75% of all vegetables and 60% of all fruits (Jaffee and Gordon, 1993; Noor, 1996). By the mid-1990's, over 500,000 Kenyan farmers and distributors earned income from this horticultural export trade, though flower production remained concentrated among commercial farmers with smallholders accounting for only 10% of floricultual exports (Kimenye, 1995; Swanberg, 1995). One of the country's fastest growing foreign exchange earners, horticultural exports have grown by a factor of 10 over the past 30 years, increasing from $13 million in 1970 to $155 million in 1999 (FAOSTAT).

Inspired by the lucrative example of Kenya's private sector exporters, private firms and donors in neighboring countries have begun to emulate the Kenyan model by attempting to break into high-value agricultural export markets. Uganda, Zimbabwe and Zambia have all emerged, in recent years, as growing participants export markets for fresh vegetables and cut flowers. In Zambia, for example, over the past 15 years exports of horticultural products have grown from $2 million to $24 million per year, while flower exports have truly blossomed, growing from $0.3 million to $43 million per year (Export Board of Zambia, 1999).

Rice production in West Africa.

Consumption of rice has surged in West Africa since the early 1960's. Fueled by growing urbanization, the advantages of reduced cooking time and lower fuelwood requirements compared to millet and sorghum, and the availability of cheap broken rice imports from Asia, rice consumption grew at an annual rate of 5.6% from 1960 through the early 1990's (Matlon et al., 1998). This surging demand has altered consumption patterns as well as production

incentives, as producers have strived to keep pace. Production has increased at an impressive 4.5% annually since 1960, mainly through area expansion. Yet imports have grown nearly twice as fast, so that imported Asian rice now accounts for roughly 40% of local consumption (Matlon et al., 1998; WARDA, 2001).

Two key episodes have triggered production breakthroughs in recent decades. First, chronologically, our respondents point to the important impact of rice market policy reforms in Mali. Second they have highlighted the exciting recent technical breakthroughs in rice breeding at WARDA which hold the potential to stimulate production surges across West Africa.

Policy reform in rice milling and marketing has radically altered opportunities and incentives for Mali's rice producers over the past decade and a half. Beginning in 1987, the Malian government, under strong pressure from Western donors, initiated a broad set of reforms in their rice subsector. Prior to that date two parastatals, the Office du Niger (ON) and OPAM, had monopolized all paddy assembly, milling and rice marketing in Mali. The key rice market reforms of 1987 abolished both these monopolies. Henceforth, farmers could sell paddy to anyone they wished, and private farmers, farmer groups and traders were allowed to set up private rice mills. As a result, small dehuller mills began to appear in the ON beginning in 1987. Since these small units operated at one-fourth milling cost of the cost of the large ON mills, volumes passing through the small dehullers grew rapidly, while the share held by large mills declined. Because of the price deregulation, private millers and retailers were free to pay different prices for different qualities of grain. Consequently, they began to offer higher prices for preferred varieties and for more carefully processed grains. The subsequent 50% devaluation of the CFA franc, in January1994, further boosted producer incentives. Import prices doubled overnight pulling up domestic rice prices sharply in their wake. Researchers monitoring these changes have concluded that the keen competition introduced by the 1987 trade liberalization forced traders to pass virtually all of the increase in consumer prices back to farmers. In the face of these new options and incentives, producers have responded rapidly. As a result of the reforms, Malian rice production has grown at 9% per year over the past 20 years, and national production has more than tripled since 1985 (Diarra et al., 2001).

Meanwhile, rice breeders at research stations throughout West Africa had struggled for many decades with the difficult problems of how to raise output of domesticated African rice under the rainfed conditions in which most farmers operate. Prior green revolution successes in Asian rice proved difficult to transfer to the West African soil and farming conditions. So with major funding from Japan, the Rockefeller Foundation, UNDP and other donors, WARDA radically altered its breeding strategy in 1991. They began an ambitious program attempting to cross African and Asian varieties of rice. In 1994, they achieved their first major breakthrough, producing a series of interspecific hybrids that combine the hardiness and weed suppression of African rice species with the high yields of the Asian varieties (Jones, 1999). The new interspecific hybrids offer many advantages to farmers: reduced labor at weeding time, drought tolerance, yield increases of 25% to 250% under farmer conditions, and short maturation of 90 to 100 days compared to 120 to 140 for normal varieties, thus permitting double cropping in irrigated zones. In 1996, WARDA began participatory varietal trials with farmers in Ivory Cost, and in 1997 they expanded these efforts to Ghana, Guinea and Togo. By late 1999, two interspecific hybrids were moving well toward varietal release in Ivory Coast. Four others were

performing well in variety adoption trials in Guinea. Seed supply for the new hybrids remains a potential bottleneck not experienced with the closed-pollinating Asian high-yielding rice varieties. So in an effort to ensure adequate seed supply, researchers have begun work with private seed companies as well as community-based farmer groups. Between now and 2004, breeders expect to release 37 new hybrids across West Africa. By 2005, they hope the new varieties will cover most of the rainfed upland rice land in West Africa. According to WARDA's lead breeder, Monty Jones of Sierra Leone, "We are on the verge of a green revolution in rice in West and Central Africa, if not throughout Sub-Saharan Africa." (WARDA, 2001)

Smallholder dairying in Kenya.

Beginning in the early 1900's, commercial white farmers in Kenya introduced exotic cattle breeds which they crossed with local species to begin commercial production of milk and butter. Encouraged by a good climate free of many livestock diseases and by favorable world prices for butter, they expanded milk production rapidly after World War I. In 1925, they formed the Kenya Cooperative Creameries (KCC), the dominant player in Kenya's milk subsector to this day (Jaffee, 1995; Mbogoh and Ochuonyo, 1992).

From the mid-1950's onward, smallholders began to emulate the commercial farmers. Rapidly growing cash incomes in rural areas stimulated steadily rising demand for milk following the expansion of smallholder tea, coffee and pyrethrum production in central Kenya in the 1950's and 1960's. Following adoption of the Swynnerton Plan for encouraging smallholder production in agriculture, the Kenyan government and donors financed a series of promotional projects supplying veterinary and artificial insemination services, extension support for intensive zero-grazing production package, and support for cooperative development (Conelly, 1998; Leonard, 1991). Rapid population growth in Nairobi further stimulated demand for milk and milk products, making smallholder dairying a highly profitable undertaking (Jaffee, 1995).

The Kenyan government established the Kenya Dairy Board in 1958 to regulated milk prices and establish government control of the KCC-dominated milk markets. Government control of urban prices led to eroding incentives during the 1980's and development of a large parallel market in milk. Subsequent decontrol of milk pricing in 1992 spurred a surge in production, sales through the KCC as well as improving availability in retail outlets (Jaffee, 1995; Mbogoh and Ochuonya, 1992; Stall et al, 1997). Although KCC market has not fully dissipated as a result of the reforms, small holders and small private processors have clearly benefited from both higher prices and higher sales volumes (Staal and Shapiro, 1998).

Dairy production in Kenya has grown at about 2.8% per year since 1980 resulting in per capita production double the levels found anywhere else on the continent (Mbogoh and Ochuonya, 1992; Staal et al, 1997). Smallholders have captured a steadily rising market share so that, today, some 600,000 small farmers operating 1 to 3 dairy cows produce 80% of Kenya's milk (Impact Assessment Group, 2000). As a result, recent panel data indicate that by the year 2000 nearly 70% of Kenyan smallholders produced milk and that it had become their fastest growing income source. Among the small farmers who produce milk, annual gross earnings

average a substantial $455 per year from milk alone, with average net earnings estimated at $370 (Tschirley, 2001).

c. Activity-specific Successes

Soil fertility enhancement.

Many African agricultural experts consider soil fertility depletion to be the fundamental root cause of declining food security across the continent (Sanchez et al., 1997; Borlaug, 1996). Studies of nutrient flows in some cotton producing zones of southern Mali and Chad indicate that soil mining accounts for 33% to 40% of the gross value of crop production, making these inherently unsustainable systems (van der Pol, 1992; Raymond, 1992). Aggregate estimates suggest that over the past thirty years, African soils have lost an average of 660 kg of nitrogen, 75 kg of phosphorus and 450 kg of potassium per hectare (Stoorvogel and Smaling, 1990). Field trials in Malawi have demonstrated that local maize varieties grown on organically rich soils give double the yield of hybrid varieties grown on poor soils, suggesting that the overriding constraint on maize production there is not germplasm but soil fertility (Carr, 1994). Several leading scientists concur, asserting that soil fertility replenishment in Africa will prove to be the key ingredient necessary for launching rapid agricultural growth in African agriculture in much the same way that improved germplasm proved essential in pre-Green Revolution Asia three decades ago (Borlaug and Doswell, 1994; Conway, 1997; Sanchez and Jama, 2000).

Widespread agreement about the importance of soil fertility gives way to sometimes heated disputes over appropriate solutions. Some specialists advocate a purely "green" revolution for Africa. They emphasize the importance of organic farming, composting, nitrogen-fixing legume crop rotations, intercropping and water conservation techniques which not only increase soil nutrients but also improve soil structure, water infiltration and microbiological activity. Though many different technologies exist, these approaches commonly operate under the collective labels of limited external input agriculture (LEIA), organic farming, or sustainable agriculture (Pretty, 1995; Reijntjes et al., 1992). Several of our respondents highlighted activities of this kind, including alley cropping with pigeon peas, minimum tillage cultivation, crop rotations with nitrogen-fixing legumes and integrated crop-livestock systems. In some settings, researchers find that farmers refuse to adopt LEIA techniques either because high labor costs make these systems uneconomic or because a shortage of organic material make them impractical (Meertens, 1999; Weber, 1996). Yet case studies in a range of African settings have concluded that in favorable locations –those with high densities of both population and organic material -- low-input farming practices can as much as double on-farm yields (Hinchcliffe et al., 1996).

A second school of thought emphasizes the necessity of moderate applications of chemical fertilizers. Only with significant doses of chemical fertilizer, they maintain, can poor farmers break the cycle of low soil fertility, expansion into marginal lands, decreased fallows and continued soil fertility depletion (Borlaug, 1996; Borlaug and Doswell, 1995; Quinones et al., 1997). Since organic sources of key nutrients often prove unavailable in sufficient quantity, and since the release of nutrients from organic sources is not timed to match plant growth spurts, strategic injections of nitrogen fertilizers can achieve far greater gains in production than will

pure reliance on soil organic material. The Sasakawa 2000 activities, currently operating in over a dozen African countries, adopt these principles most clearly. Mentioned by several of our respondents, these efforts commonly increase yields by over 100% and have been credited with contributing to the large aggregate surge in Ethiopian agriculture during the 1990's (Quinones et al., 1997).

A middle ground, which emerges frequently in practice, emphasizes the benefits of a combination of organic, mineral and chemical fertilizers to enhance soil fertility. The conservation farming efforts in Southern Africa include strategically timed topdressing of nitrogen fertilizer in planting holes prepared with organic materials. In general, evidence indicates that chemical fertilizer response rates improve substantially in organically rich soils (Pichot et al., 1981; Palm et al., 1997). Though they are often associated with chemical fertilizers, the Sasakawa 2000 efforts also involve active encouragement of organic solutions as with their efforts to expand mucuna relay cropping in Benin (Vissoh et al, 1998). A recent review by Sanchez et al. (1997) most explicitly advocates the benefits of an intermediate model of soil fertility enhancement which includes a combination biological, mineral and chemical inputs. In their view, phosphorus replenishment can most economically be achieved by mineral based rock phosphate applications with biological supplementation, while nitrogen replenishment will derive mainly from biological sources coupled with strategically timed chemical fertilizer supplementation.

Most commonly cited among the experts we polled was an intermediate system of soil fertility enhancement involving improved 1 to 2 year fallows with nitrogen-fixing leguminous shrubs coupled, where available, with an application of local rock phosphate. Spearheaded by the International Center for Research on Agroforestry (ICRAF), these efforts have involved joint research with a series national agricultural research systems in Kenya, Malawi, Tanzania, Zambia and Zimbabwe (Kwesiga et al, 1999; Rao et al, 1998). Together with a variety of NGOs, researchers have involved farmers in field trials and extension. To date, the greatest impact has emerged in Southern Africa where about 20,000 farmers in the Zambezi basin currently practice these improved fallow systems, though similar efforts are under way in East and West Africa as well (Duguma and Mollet 1997). Results to date suggest that these improved fallows alone can double maize yields for up to three seasons, while collateral application of rock phosphate may as much as quadruple maize output (Sanchez and Jama, 2000).

From this broad range of promising initial efforts, the challenge becomes one of how to identify which techniques will prove attractive to farmers across a broad range of specific settings. Comparative work such as that undertaken by Bationo et al. (1998), Buresh and Cooper (1999), Dakora and Keya (1997), Franzel (1999), Nwanda an Bekunda (1998) and Padwick (1983) will prove instrumental in identifying which technologies will work best in different settings.

d. Institution Building

Farmer organizations.

Institutions for channeling collective action by farmer groups represent an important form of social capital. In combination with other key assets -- the natural resource base, human capital, physical assets, and financial capital -- this organizational infrastructure offers a key resource on which farmers can draw to initiate, design and finance improvements in their agricultural system (North, 1990; Ostrom, 1990; Ruttan, 1988; Uphoff, 1986). Increasingly, students of agricultural development emphasize the benefits of collective action by farmers in a wide range of spheres, including the design, financing and execution of infrastructural investments, technology development and dissemination, irrigation management, natural resource and common property management, and direct political action (Buisrogge, 1989; CIRAD, 1995; Merrill-Sands and Collion, 1994). For this reason, many donors and NGOs increasingly view support to these grass-roots organizations as central elements of their efforts to promote African agriculture (CIRAD, 1995; Veit et al., 1995).

Many of our survey respondents highlighted the important role farmer organizations can play in promoting growth, sustainability and equity. Among institution-building investments, they mentioned farmers organizations with a frequency second only to that of agricultural research (Table 3). As they note, collective action by farmers can improve agricultural opportunities in a number of important ways. *Infrastructure provision:* Farmer groups in Burking Faso, the Groupements Naam, constructed stone dikes to harvest water and retain topsoil thereby enhancing the private profitability of improved sorghum and fertilizer packages (Smale and Ruttan, 1997). Similarly, Ethiopian farmers in the village of Ginchi pooled their labor and resources to construct a central drainage canal necessary to enable collective use of a lowland watershed (Gaspart et al., 1998). *Technology development and dissemination:* By incorporating farmer knowledge and priorities, farmer groups can help focus researcher on critical issues and thereby speed solution of critical farmer problems, as they did in the Casamance region of Senegal. By helping to organize on-farm trials, farmer groups can greatly expand off-station testing and reduce researcher logistics and cost, as they did with cowpea research in Burking Faso (Bebbington et al., 1994; Merrill-Sands and Collion, 1994). *Irrigation development and management:* In addition to the many examples cited by Uphoff (1988), one of our respondents underlined the importance of water users' associations in managing smallholder irrigation schemes in Niger. *Natural resource and common property management:* Village associations in Liberia manage local fishing rights in Kapaai District to prevent overfishing during the spawning season. In the presence of ineffectual new legislation, traditional leaders continue to manage grazing and water access rights in order to prevent overgrazing in the Butana Region of Sudan (Veit et al., 1995). *Policy change:* In Zimbabwe, during the first half of the 20^{th} century, the large-scale Commercial Farmers Union successfully lobbied government for strong national research system, public investment in roads and guaranteed farm prices that laid the foundation for widely heralded breakthroughs in hybrid maize production (Eicher, 1995). Similarly in the early 1990's, small farmers in Mali's cotton zone successfully lobbied for changes in policies governing cotton production and marketing and have retained a permanent seat in ongoing policy debates (Bingen, 1998).

The impact of these diverse efforts often proves difficult to measure. Clearly, standard problems of competing interests, externalities and temptations to free riders impede participation in many instances (Campbell et al., 2001; Gaspart et al., 1998). Even so, participants and researchers have reported impressive results in many cases. The Groupements Naam in Burkina Faso successfully provided water control for several thousand hectares of farmland using labor-intensive methods and without any state investment (Smale and Ruttan, 1997). In technology development and dissemination, many specialists state categorically that, "There is mounting and compelling evidence indicating that user participation is a critical ingredient for innovative, relevant and efficient technology development" (Merrill-Sands and Collion, 1994). Attesting to the power of farmer groups in natural resource management, one of our respondents offers this flattering assessment of a program in Mali, stating that "I was involved in a rapid appraisal of farmers having participated in this program. The rapid appraisal showed that by combining natural resource management practices (primarily anti-erosion investment and improved use of organic matter) farmers had substantially increased yields, aggregate production, incomes and general well-being. Outmigration of young farmers from the zone has diminished considerably and these young farmers are now excited about agriculture and becoming serious commercial farmers. They are frequently the driving force behind the revitalized farmers' associations in the zone which are now negotiating input credit directly with the banks." Potentially even more important are the indications of successful political action by farm groups. Recurrent funding for key agricultural research and support institutions will require ongoing political commitment, a support most effectively fueled by the sustained political voice of farm groups and lobbies. In that sense, small farmer activism, such as that in the cotton zone of Mali, may prove central to ensuring continued public support for key agricultural policies as well as a prerequisite for the continued health and survival of vital agricultural research and support institutions.

Agricultural research capacity.

Public investments, during the 1960's and 1970's, in scientific manpower and agricultural research institutions enabled African NARs to ramp-up their research capacity substantially. As a result of this large-scale infusion of public funding, by donors and African governments, the numbers of trained African scientists working in national agricultural research organizations expanded rapidly in the years following independence. In 1960, about 2,000 scientists worked in African NARs with fully one third of these working in South Africa alone. Of the two-thirds working outside of South Africa, 90% were expatriates. By the early 1990's, the situation had changed radically. Total research staff had more than quadrupled, to about 9,000, while expatriate staffing had fallen to 10% (Pardey, Roseboom and Beintema, 1995).

The growing scientific capacity of national agricultural research systems has enabled scientists to introduce a steady stream of innovations into African farming systems. Given research lead times measured in decades rather than years, many of the fruits of post-independence capacity building began to reach farmers in the mid-1980's (Masters et al., 1998). Early breakthroughs during the 1960's, as in Zimbabwean and Kenyan maize breeding programs, built on two to three decades of pre-independence research. Overall with maize, African NARs released 300 new varieties to small and large farmers across the continent in the 25 years up to 1990 (Byerlee and Jewell, 1997). The Kenya Agricultural Research Institute (KARI) alone

introduced thirteen new varieties in the decade following its 1963 releases (Hassan and Karanja, 1997).

The impact of these innovations has proven considerable. Economic assessments report generally high rates of return to agricultural research in Africa. One review of 32 agricultural research evaluations finds rates of return in excess of 20% for three-fourths of the studies conducted, with a median rate of 40% (Masters et al., 1998). A more recent review of 44 cases computes a median rate of return of 37% to agricultural research and 27% to agricultural extension in Africa (Evanson, forthcoming). These rates of return, comparable to those found in Asian agriculture, suggest that investment in agricultural research represents one of the most productive available uses of public investment in Africa.

To maintain these highly productive agricultural research systems requires more than a one-time investment in skilled staff. To perform effectively, they require sustained operating budgets that will enable them to respond to an ever-changing physical and policy environment. Sporadic and fluctuating funding sources have proven a serious impediment to the effective performance of this basic responsibility. For example, the drastic cuts in Kenya's maize research budgets in the late 1970's reduced the flow of new maize varieties by a factor of six, from 13 during the 1960's to only 2 during the 1970's. This, in turn, contributed to a perceptible slowdown in the expansion of maize production during in the 1980's (Hassan and Karanja, 1997). In general, as in Kenya, recurrent funding for African agricultural research has not kept pace with staffing increases. Though recurrent budgets for agricultural research increased steadily though the mid-1970s, they have stagnated thereafter. As a result, donor support now accounts for about half of African recurrent research expenditures outside of Nigeria and South Africa.[5] Overall spending per scientist has fallen over 30% below its 1960 levels (Pardey et al, 1999). Wilting salary scales, coupled with falling budgets for research materials and transport, have eroded incentives and hampered system performance in recent years (Eicher, 1999). Meanwhile, new areas of technical expertise – such as intellectual property rights, biotechnology and computer-aided research methods – demand renewed investments in human skills. Consequently, a second round of investment in human scientific capacity, coupled with enhanced recurrent budget support, will prove essential in sustaining a productive agricultural research establishment in Africa into the coming decades (Eicher, 2001).

[5] This figure falls to one-third if the largely government-funded Nigerian and South African research systems are included.

Table 8. Summary of Selected Major Successes in African Agriculture

Topic Region	Time period	Intervention	Key actors	Incentives	Impact	Determinants of success	References
Africa-wide commodity successes							
Cassava							
General Africa	1550-1800s	• introduction from Brazil • broad diffusion	• Portuguese traders • farmers, tribal leaders	• food security	• became dominant staple for 200 million Africans	• drought and locust resistant • year-round production on marginal soils • low labor requirements	Jones (1957, 1959)
General Africa	1920's-30's	• breeding and distribution of disease-resistant varieties	• colonial research stations	• threat to major food crop	• put cassava on researchers' agenda	• superior technology • simple, vegetative propagation	Cours et al (1997)
General Africa	1970's-80's	• biological control of mealybug via mass rearing and introduction of natural predators	• IITA, CIAT, IICB, NARs, donors	• deadly threat to dominant staple	• $2.2 billion in production saved • B/C ratio of 149	• self spreading control with zero cost to farmer • IARC-NAR collaboration • strong donor support	Norgaard (1988)
HYV maize							
Southern Africa	1960-	• hybrids developed	• NARs, CIMMYT, commercial farmers, seed companies	• staple food production	• Zimbabwe maize production grows 8% annually during the 1960's	• superior technology • assured fertilizer and seed supply • reliable markets	Miracle (1966) Eicher (1995)
East Africa	mid-1960's-	• hybrids developed	• NARs, CIMMYT; seed companies	• staple food production	Kenya 1963-73: production doubles; $1 billion production gains	• superior technology • assured fertilizer and seed supply • reliable markets	Gerhart (1975) Morris (1998)
West Africa	1980's-	• improved open-pollinating varieties	• NARs; CIMMYT	• staple food production	4.5% annual production growth over 20 years	• superior technology	Byerlee (1994) Byerlee and Eicher (1997)

Livestock vaccine							
General Africa	1986 on	• development and distribution of an effective rinderpest vaccine	• IBAR, NARs, donors, national veterinary services	•protect a key agricultural asset	• $50 million in production gains in 10 countries evaluated • B/C ratio 1.8	• superior vaccine developed • determined international collaboration, technical and financial	Mack (1970) Plowright and Ferris (1962) Provost (1982) Tambi (1999)
Region-specific commodity successes							
Bananas							
Central Highlands	500 on	• selective breeding by farmers	• farmers	• food security • combat erosion	• launched an agricultural and demographic revolution in the region	• favorable climate • low labor inputs	Reader (1997) Schoenbrun (1993)
	1990s	• tissue culture development of improved varieties	• NARs, ISAAA, donors	• combat pests and disease	• doubles farmer income and yields	• rapid production of disease-free planting material	Qaim (1999)
Cotton							
Francophone West Africa	1960s on	• vertically integrated support to small farmers: input supply and guaranteed output price and marketing	• CFDT and mixed public/private successors • African governments • French govt	• motor of rural development efforts • export revenues	• production growth of 6.5% per year over past 40 years • export revenues of $100 to $160 million per year for major exporters	• guaranteed input supply • guaranteed market and price • sustained research in improved varieties • strong government commitment to key support institutions	Roberts (1996) Courtant (1991) Lele et al (1990) Coton et Développement (1999) Teft (2001)
Horticulture							
East Africa, initially in Kenya	1970 on	• export of high-value horticulture and flowers • contract farming • some donor marketing assistance	• private exporters	• lucrative income earner • foreign exchange	• Kenya horticulture exports $155 million per year • over 500,000 farmers earn income	• rapid cash flow for farmers (50 days for green beans) • guaranteed market • no government interference	Jaffee (1995) Swanberg (1995)
Smallholder dairy							
Kenya	1950 -	• improved breeds and veterinary services • extension of zero-forage packages • marketing support • price decontrol	• Kenya Cooperative Creamery (KCC), Kenya Dairy Board (KDB), coops, govt, donors	• equity • highly profitable for smallholders	• over 600,000 smallholders now supply 80% of Kenya's milk	• disease-free climate • rapidly growing demand • large farmers test technologies and establish infrastructure • improved breeds • price decontrol in 1992	Jaffee (1995), Mbogoh and Ochuonyo (1992), Staal and Shapiro (1998)

Rice West Africa	1980's	• policy reform in Malian rice markets	• government, donors, parastatals	• improve efficiency and production incentives	• 9% annual growth in rice production since 1980	• government commitment • good market monitoring systems	• Diarra et al. (2001)
	1990's	• breeding of interspecific hybrids	• WARDA, donors	• improve productivity of major food	• potential green revolution in West African rice	• superior technical package • strong donor support • participatory field trials	• Jones (1999) • WARDA (2001)
Activity-specific successes							
Soil fertility enhancement	1980s on	• controlled fallows with nitrogen-fixing legumes, rock phosphate applications	• ICRAF, NARs, NGOs	• sustainability	• increased yields of 100% to 300%	• identification of appropriate technologies for specific settings • farmer-researcher interaction	Sanchez et al. (1997) Padwick (1983)
Institution building							
Farmer organizations General Africa	1970s on	• collective action by farmers in building infrastructure, testing technology, common property management and policy debate	• farmer groups • NGOs • donors	• develop superior technology • equity • sustainability	• stone dikes in Burkina provide water for 2,000 hectares • cotton farmers lobby for policy change in Mali	• strong leaders • coalesced interest around a common objective	Bingen (1998) CIRAD (1995) Merrill-Sands and Collion (1994) Smale and Ruttan (1997) Veit (1995)
Agricultural research General Africa	1960s to 1980s	• large-scale training • institutional support	• donors, universities, governments	• absence of trained scientists at independence	• 7,000 African scientists trained over 30 years • median returns to ag. research 37%	• strong early commitment by donors and governments • recurrent support now flags, requiring urgent attention	Eicher (1999, 2001) Pardey et al. (1999) Masters et al. (1998)

Source: IFPRI Expert Survey, 2000.

5. THE DYNAMICS OF CHANGE

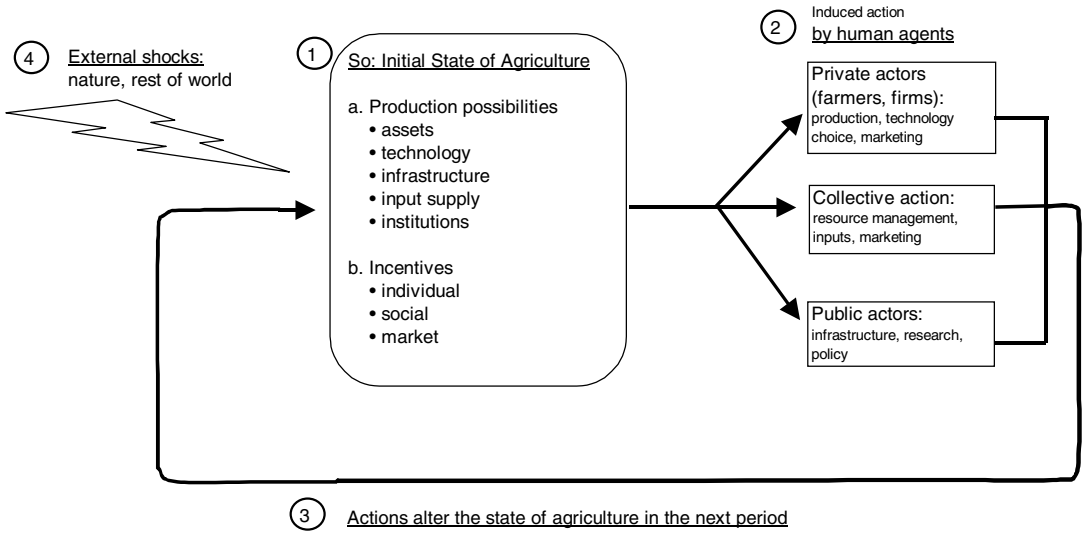
a. Analytical framework

Agricultural systems evolve continuously as individual crops and their human managers respond to ever-adapting pests, diseases, weed species and environmental conditions (Harlan, 1992; Rindos, 1984; Smith, 1995). In the wild, plant and animal species respond genetically as they seek to adjust successfully to their changing environment. In contrast, human managers assume responsibility for the reproductive success of domesticated plants and animals, as farmers and their supporting research and operational institutions pursue both genetic and agronomic solutions to ever-evolving competitive threats.

In this inherently dynamic system, two key structural features of the agricultural system govern human responses at any given point in time (Figure 2). First, production possibilities place initial bounds on the scope of action available to farmers. These opportunity sets depend on the available quantity, productivity, and distribution of key productive assets such as land, labor, capital, and water; on the stock of available biological and agronomic technology; on the state of physical infrastructure; and on supporting institutions for resource management, input supply and marketing. Then, from within the available opportunity sets, prevailing incentive structures subsequently determine which of the many available options farmers, marketing agents, collective institutions and public agencies will select. Incentives such as enhanced food security, social solidarity or risk reduction influence individual and household decision-making, while market prices affect both input supply as well as production, storage, processing and marketing of outputs.

Three groups of human agents participate in agricultural systems, responding to changes and in turn influencing successive stages of this dynamic evolutionary sequence. Private actors include individual farmers, agribusinesses, and non-governmental organization (NGOs) who, together, determine crop mixes, technologies adopted, production and marketing outcomes. Collective action and institutions -- such as common property management schemes, farmer associations, cooperatives, trading networks, and rotating credit associations -- help manage land and water resources, markets and input availability. The public sector -- including national and international research institutes, parastatal agencies, governments, and donors – influence policies, technology, infrastructure and the policy environment.

Figure 2 -- The Dynamics of Agricultural Change



These actions, undertaken each cropping season, alter opportunity sets and incentives in the next period, thereby eliciting another round of responses in a continuous succession of change: agricultural research in one period leads to availability of new varieties in the next; farming practices one season aggravate soil erosion or nutrient depletion down the road; new policies alter prices or availability of key inputs in the coming seasons. As this evolutionary sequence unfolds, external shocks -- such as natural disasters, change in rainfall, disease, pest adaptation, and advances in human medicine – likewise alter the state of both opportunities and incentives (Figure 2). The case most frequently cited among our survey respondents, that of the cassava mealybug, altered incentives, priorities and opportunities urgently and dramatically. The resulting sequence of decisions and adaptations by human and biological agents traces out a dynamic path for agricultural growth (Figure 3).

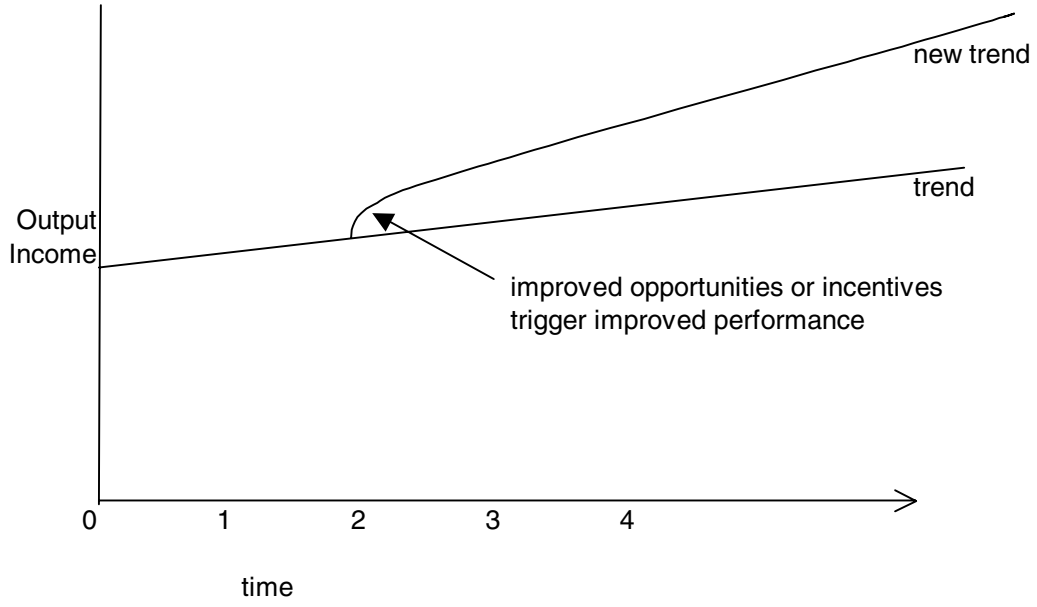
b. Key interventions triggering change

To propel agricultural systems up onto a higher growth path, interventions must alter either production possibilities or incentives. But which matters most?

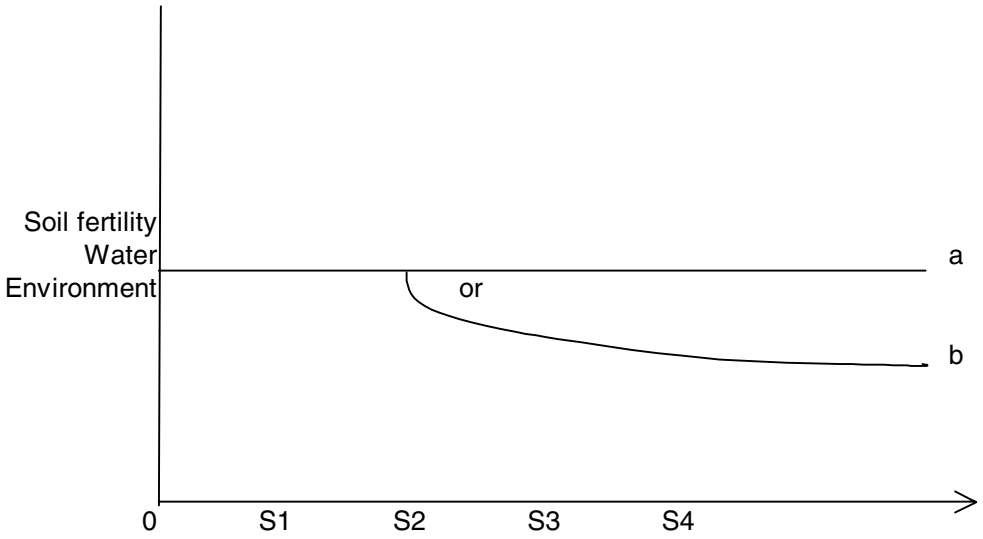
In our expert survey, respondents generally underlined the importance of the first set of interventions, those expanding production possibilities. As shown in Table 9, three-fourths of the stimuli identified by our respondents involved expanding farmer opportunity sets, occasionally through improved asset holdings (improved soil fertility, irrigation facilities, farm equipment, and land rights) but most prominently via improved technologies and access to key technical knowledge and inputs.

Figure 3 -- Growth Path of an Agricultural System

A. Trends in agricultural production



B. Evolution of the asset base



[a] sustainable growth
[b] soil mining, unsustainable

Table 9 -- Key Interventions Triggering Agricultural Change

Actors	Respondent Categories* Technical researchers	Social Scientists	Implementors	Government /donors	Total
A. Improving opportunities					
Increase farmer assets					
soil fertility	6%	3%	7%	3%	5%
irrigation	1%	2%	8%	6%	4%
farm & processing equipment	0%	1%	7%	4%	3%
land rights	2%	1%	0%	0%	1%
draft power	0%	0%	2%	2%	1%
subtotal	9%	8%	***23%***	15%	13%
Develop new technology					
higher productivity	30%	27%	22%	19%	25%
disease resistance	15%	0%	2%	7%	5%
introduce new species	2%	0%	2%	0%	1%
other	3%	0%	5%	8%	3%
subtotal	***50%***	27%	***31%***	***35%***	***34%***
Improve access to superior technologies					
extension	13%	15%	18%	8%	14%
seeds	7%	8%	5%	17%	9%
fertilizer and pesticides	7%	0%	2%	1%	2%
credit	3%	3%	6%	3%	4%
subtotal	30%	27%	31%	29%	29%
B. Improving incentives					
macro policy (devaluation, trade liberal	0%	9%	0%	3%	4%
agricultural policy (market reform, taxa	9%	9%	2%	4%	7%
private marketing	2%	7%	4%	6%	5%
public marketing agencies	0%	7%	5%	6%	5%
growing markets	1%	5%	4%	2%	3%
subtotal	12%	***38%***	15%	21%	25%
Total interventions identified					
percent	22%	39%	20%	19%	100%
number**	111	202	103	98	514

* Differences among respondent categories are significant at the 1% level.
** Because many respondents cited multiple interventions, the totals here exceed the total number of cases proposed.

Source: IFPRI Expert Survey.

In most of the success stories discussed above, new technology played a crucial role in expanding farmer incomes: development of high-yielding varieties of maize, first in Zimbabwe and Kenya in the 1960's then more broadly in East and Southern Africa in the 1970s and 1980s; fighting diseases in cassava with resistant varieties in the 1930s and with still newer varieties and biological controls in the 1990s; development of a vaccine to cure rinderpest in livestock; introduction of improved seed, fertilizer and animal traction packages in West African cotton during the 1970s and 1980s; farmer introduction and selection of improved varieties of bananas in the Central Highlands from the first century A.D. and more recently through scientific advances in tissue culture; interspecific varieties of rice in West Africa in the 1990's. Availability of key inputs proved essential

in many cases as well, notably with the maize seed industries in East and Southern Africa (Morris, 1998); the development of private and public distribution systems for rinderpest vaccine in livestock; and with the vertically coordinated input packages in West African cotton and East African horticulture.

Improved incentives, the second potential lever for inducing change, emerged as an important initiator of change in the remaining one-fourth of cases cited (Table 9). This share rose to nearly 40% among social scientists, who consistently highlighted the importance of policy reforms in triggering growth in agricultural systems.

Non-market incentives mattered most in several cases involving food staples. In the important cases of cassava and bananas, household food security imperatives provided strong inducement for the initial introduction, breeding and dissemination by farmers. Compelling food security incentives have likewise induced decisive action by NARs and IARCs in order to prevent famine in recent decades. In these cases, markets and prices played little role in mobilizing action and ensuring success of these efforts. Critical and widespread demand existed on millions of farms across the continent and among the urban poor.

In contrast, with tradable commodities such as cotton, horticulture, and maize, active market promotion and assurance of price incentives has played a major role in stimulating increased output. Many respondents noted the importance of the CFA devaluation in stimulating cotton exports in the 1990s. Vertically integrated export marketing proved crucial in the rise of private horticultural exports from Kenya and cotton from French West Africa. Processing in Kenyan smallholder dairies and maize marketing proved essential in sustaining incentives for local producers.

Surveyed experts remain mixed in their preference for private as opposed to public market makers. Many underlined the importance of government absence from all phases of the horticultural boom in East Africa and for their exit from cocoa and coffee marketing in West Africa. Yet others highlighted the importance of links between the parastatal and private sectors in West African cotton and in the rapid early growth of cotton and tea exports from East Africa.

c. Private actors

Farmers.

Individual farmers have played a central role in stimulating improvements in African agriculture. The introduction and dissemination of both cassava and maize was a purely private affair. Following its introduction by Portuguese traders in the late 1500's, farmers and traders distributed cassava widely into the interior where, by all accounts, it was well established before the arrival of European explorers. Similarly with bananas, plant breeders marvel that farmers in Uganda and surrounding countries have bred so selectively that, after roughly a century of on-farm selection, the Central Highlands of Africa house the largest genetic diversity of bananas in the world (Reader, 1997). As one

respondent noted, the expansion of banana production, "has depended solely on selective breeding by farmers. It now covers the entire Great Lakes region and is the number one food security staple in the region."

In 14% of the case studies nominated, farmers and farmer groups proved to be key initiators of system change (Table 10). One respondent, for example, emphasized how technical innovation by farmers in Sukumaland, Tanazania, in response to liberalization of food markets and declining profitability of cotton, has led to rapid expansion of rice production over the past decade. Farmers there now produce over one million tons of rice annually (Meertens, 1999). Likewise, farmers can play a key role in technology diffusion, as they did in the case of the recent introduction of an improved dual-purpose (food and fodder) cowpea in Bunkure area of Kano State, Nigeria. In describing this case, one of our respondents emphasized, "It's current widespread cultivation by thousands of farmers started from one farmer and continued to grow exponentially without the intervention of institutional extension agents." Among respondent groups, implementers of promotional activities most frequently considered farmers and farmer groups important, with farmer importance rising to 20% in the cases they cited.

Private agribusiness.

Seed supply industries have proven crucial to the maintenance of high-yielding hybrid maize varieties throughout East and Southern Africa. Private exporters have sustained horticulture exports of flowers, vegetables and tropical fruits from East Africa to Europe and the Middle East through export marketing and often through input supply to farmers. Large-scale dairy producers in Kenya provided invaluable testing grounds for intensified milk production later adopted by smallholders, while dairies themselves provided crucial markets for small and large producers alike. Private veterinary services played a crucial role in delivery of vaccines and veterinary services across East and Southern Africa .

Common to many of these systems are what the agricultural marketing literature calls "system nodes," where large commercial firms provide key inputs or market outputs that sustain production by thousands of small producers (Boomgard et al., 1992; Delgado, 1999). The case of horticultural exports from West Africa offers one of many similar examples. Following the devaluation of the CFA franc in West Africa, one respondent noted, "the rapid supply response displaced large amounts of European imports of horticultural products in West African coastal markets. Production increase took place through private sector initiative, with very little government involvement." Clearly, these commercial firms can and do play a crucial enabling role necessary for the advance of smallholder agricultural production. Respondents identified these private firms as key instruments of change in 11% of the cases cited, with this figure rising to 15% among African government and donor respondents (Table 10).

Table 10 -- Key Actors Initiating Change in Agriculture

Actors	Respondent Categories* Technical researchers	Social Scientists	Implementors	Government/donors	Total
Public sector					
African					
national agricultural research systems	***28%***	13%	***22%***	***21%***	20%
government	23%	***28%***	12%	15%	21%
parastatals	1%	3%	5%	6%	3%
International					
donors	8%	17%	12%	17%	14%
international agricultural research cen	18%	8%	5%	12%	11%
subtotal	78%	68%	55%	71%	69%
Private sector					
agribusiness	6%	10%	12%	15%	11%
farmers	9%	8%	12%	3%	8%
farmer groups	3%	9%	8%	3%	6%
NGOs and projects	4%	5%	13%	8%	7%
subtotal	22%	32%	***45%***	29%	31%
Total actors					
percent	100%	100%	100%	100%	100%
number	78	116	60	66	320

* Differences among respondent categories are significant at the 5% level.
** Because many respondents credited multiple actors in the cases they cited, the totals here exceed the total number of cases identified.

Source: IFPRI Expert Survey.

NGOs and projects.

Though less frequently cited than the other private sector actors, with 7% of overall citations, non-governmental private agencies have many times played important strategic roles. In the ICRAF experiments with controlled fallows, NGOs have proven valuable partners in testing and disseminating new soil management techniques. Likewise with the spread of conservation farming techniques in Southern Africa, NGOs have emerged as key partners in technology extension and work with farmer groups. Donor-financed projects have helped exporters establish marketing contacts that contributed to rapid emulation and growth of cut flower and horticultural exports from East Africa. And CIAT's efforts to expand climbing bean seeds distribution networks in the central highlands benefited from close cooperation of NGO's, church groups, clinics and schools (Sperling, 1994; Sperling et al., 1995).

Though some observers remain skeptical that NGO's can replace government extension services (Eicher and White, 1999), many respondents in our survey cite cases in which NGO projects provide extension support to understaffed and under-funded government extension services. Their importance emerged most prominently among citations supplied by project implementers, where they accounted for 13% of actors identified as agents of change. Ultimately, the thorny issues of public salary levels, recurrent transport budgets and adequate staffing for government extension services remain closely linked to the debate over the relative role of NGOs in African agriculture.

d. Public actors

Though private actors have made invaluable contributions to agricultural growth in Africa, many necessary interventions remain public goods. Underlining the importance of this public role in African agriculture, our respondents identified the public sector -- which includes national and international research centers, governments, parastatal agencies, and donors -- as key initiators of change in over two-thirds of the instances cited (Table 10). Agricultural research in open pollinating crops, agricultural extension, and the provision of roads and communications infrastructure represent key investments that the private sector will not initiate or for which private incentives alone will lead to under-investment (Alston et al., 1998). Taxation, exchange rates and other macro policies likewise prove powerful instruments for influencing agricultural incentives, and these tools, too, remain squarely in the public domain.

Government.

Government policy makers, agricultural ministries and extension services received 21% of all citations for initiating favorable change, making them the most commonly cited actors overall. Social scientists, in particular, cited government most frequently, not surprising given their focus on the importance of government policies in stimulating agricultural change. Indeed, many ingredients essential for agricultural growth – research, extension, and rural infrastructure – are public goods requiring state intervention and support. A favorable policy environment likewise requires collective decision-making that only national governments can provide. Many respondents cited the importance of the CFA franc devaluation of the early 1990's in reviving cotton and horticultural exports from West Africa. Others mentioned the food policy reforms in East and Southern Africa as crucial ingredients promoting increased competition in milling industry and improved access to low-cost nutritional food for low-income groups during the 1980's and 1990's (see Jayne et al., 1995, 1996; Jayne and Jones, 1997).

At the same time, in other cases, the absence or withdrawal of the government can prove to be a favorable catalyst of change. Several respondents working in East Africa echoed the sentiment of one who stated flatly that, in promoting horticultural production and export, "What most people say is that the industry flourishes because there was never government involvement." The key, as in most of economics, is finding the right balance between public and private roles (Johnson, 1995).

National agricultural research centers (NARs).

The role of national research centers in stimulating change in African agriculture received the second highest share of citations overall (20%). In fact, they received the highest share from all groups except social scientists, whose focus on policy issues led them to emphasize the importance of government policy actions (Table 10). In most of the successes discussed above – maize, cassava, rice, livestock, dairy and bananas – NARs regularly contributed key new technology to farmers' stockpile of options.

International agricultural research centers (IARCs).

International agricultural research centers received high marks for their interaction with national research systems, for supplying germplasm and technical assistance, and in rallying donor support around key priorities, most emphatically in the recent outburst of cassava mosaic virus and pest infestations, in long-term contributions to the improvement of hybrid maize lines, in the recent development of interspecific varieties of rice and in promoting promising new techniques of soil fertility enhancement via controlled fallows and limited applications of mineral fertilizers. Respondents also noted important contributions in tissue culture improvements in bananas, improved dairy breeds and management, in the development of improved livestock vaccines, and improved varieties of groundnuts and climbing beans. Overall, the share of citations received by international agricultural research centers comes to 11% of the total, with that figure rising to 18% in the case of technical researchers who work most closely with the international centers.

Donors.

Respondents identify donors as key agents of change 14% of the time, though social scientists, African governments and donors themselves that share rises slightly. The entirety of the international agricultural research system as well as one-third[6] of African NAR budgets are now donor-financed. So, currently, donors play a crucial role in sustaining international agricultural research and technology transfer. Several respondents noted the long time lags involved in agricultural research –11 years in one FAO project, 17 years in Malawi's maize breeding, 28 years for Zimbabwean maize -- and applauded the long-term donor funding horizons necessary to support viable research results. Others point to specific donor pushes to assist with programs such as livestock vaccination, the urgent battle against the cassava mealybug, promotion of horticultural exports and dairy production.

e. Determinants of success

Across a diverse set of individual cases, over time and across the continent, the role of new production technology resurfaced continually as a fundamentally important instrument of change. Development of superior new production technology emerged as the most important determinant of agricultural success among all respondent groups except the social scientists (Table 11). Improved technology proved a key ingredient in boosting production of virtually all the commodities successes stories: maize, cassava, rice, cocoa, livestock, cotton, dairy, horticultural products and bananas. And in innumerable more specific examples, respondents identified technologically induced agricultural advances. They point to biotechnology breakthroughs in Kenyan sweet potatoes and South African cotton, improved varieties of groundnuts and climbing beans distributed throughout Southern Africa and the Central Highlands, respectively,

[6] That figure rises to one-half if we exclude the largely state-financed systems of Nigeria and the Republic of South Africa (Pardey et al., 1995).

Table 11 -- Determinants of Success

Determinants Identified	Respondent Categories* Technical researchers	Social Scientists	Implementors	Governmen t/donors	Total
Superior new technology	***31%***	14%	17%	***23%***	21%
Collaboration	***20%***	16%	14%	***22%***	18%
farmer-researcher	6%	3%	8%	3%	5%
NAR-international centers	10%	1%	1%	5%	4%
farmer-private companies	3%	3%	4%	3%	3%
farmer groups	0%	3%	0%	3%	2%
other	2%	6%	1%	7%	4%
Market access for output	9%	***25%***	10%	13%	15%
Favorable policy environment	7%	***21%***	9%	12%	13%
Availability of key inputs	13%	10%	12%	11%	11%
Political commitment	8%	7%	***12%***	6%	8%
Favorable ecology	6%	3%	***10%***	6%	6%
Strongly felt need for action*	5%	1%	6%	3%	4%
Strong management	2%	3%	***9%***	3%	4%
Total					
percent	100%	100%	100%	100%	100%
numbers	103	118	77	94	392

Bold italics indicate above-average representation.
Underlining indicates below average representation.
* Differences in reported determinants are significant at the 1% level.

Source: IFPRI Expert Survey.

development of nutritionally superior varieties of maize in Ghana, clonal coffee in Uganda, yam minisett technology in Nigeria, and Russian wheat aphid control in dryland wheat in South Africa.

Collaboration emerged as the second most prominent determinant of success[7] – again among all respondents with the exception of the social scientists. Respondents most commonly cited collaboration among researchers and farmers; among NARs and IARCs; and among extension staff, NGOs, farmers and researchers. Given the small size of many African countries, collaboration among NARs themselves garnered multiple mention as well. Indeed a series of regional research networks has developed in recent

[7] Possibly as a caution against too much of a good thing, one respondent, a technical scientist, noted that a key to the success in the biological control of the cassava mealybug was exactly that it did *not* require any participation. In the respondent's words this was a, "research topic with results that did not require the participation of whosoever. The result 'established' itself and did not require any PTD or other participatory approaches."

years to foster such exchanges enabling the system to move away from the insular days when less fluid communication flows diluted scarce research resources though unnecessary duplication (Cours et al., 1997).

Markets and a favorable policy environment emerged as the most prominent determinants of success in the cases cited by social scientists. This comes as no surprise, given their disciplinary inclination to cite policy successes market institution-building far more frequently than the other respondents (Table 6). Among marketing activities, respondents repeatedly identified maize marketing agencies and price incentives as crucial determinants of increases in farmer production. In the export markets for cotton and horticultural products, marketing links proved crucial as well. With smallholder dairying, respondents highlighted the importance of smallholder links to local processors, and via them to consumer markets.

Yet in three important cases – cassava, livestock vaccine, and bananas – markets did not emerge as prominent constraints. For cassava and bananas, the food security needs of millions of farmers proved sufficient inducement for technology development and adoption. Similarly with livestock vaccine, the intense felt need of producers to preserve this valuable store of wealth, proved a sufficient inducement for technology development and adoption. In these three cases, output markets did not emerge as prominent determinants of success. For cash crops, however, market access and incentives clearly do matter.

In the policy arena, respondents cited the importance of macro-economic policies, particularly the salubrious impact of the CFA devaluation in francophone Africa. They also noted a wide variety of specific agricultural policies, ranging from land tenure reforms, to livestock trade agreements, subsidy introductions and withdrawals, and agricultural taxation. A supportive macro policy environment underlay Malawi's recent surge in hybrid maize production; but, one respondent noted, "when this changed, the 'success' did not look so exciting."

Availability of key inputs was likewise identified as an important determinant of success among all respondent groups. In the case of rinderpest vaccine, distribution via public and private veterinary services proved the focus of the intervention. With cotton and horticulture production, vertically integrated firms frequently provide both inputs and purchase outputs. And in the ubiquitous maize examples, seed availability becomes a sine qua non for successful adoption in East and Southern Africa where hybrids have historically dominated the research establishment.

Implementers raised three very practical issues far more frequently than other respondent groups. They highlighted the importance of political commitment, favorable ecology and strong management. "Management is the key word here. The scheme was well managed, with the farmer in mind as the most important person in the whole process," offered one respondent in explaining the success of a farm credit program from Kenya. Another, discussing a farmer support program in South Africa asserted that, "Institutional commitment, personal commitment and a focus on human capacity

contributed to fascinating success in selected areas." In spite of this different weighting, the implementers still considered superior technology and onfarm collaboration with farmers as most important determinants of all.

6. BUILDING ON PAST SUCCESS

Despite the pessimism of the outside world, African agriculturalists remain keenly attuned to the importance of their mission and optimistic about the impact they have achieved in a wide variety of focused interventions across the continent. The challenge now is to build on these individual, commodity-specific success stories and translate them into sustained, system-wide improvements in agricultural performance.

This will require well-staffed, adequately funded technical, operational and policy-making institutions. Africa's agricultural establishment has come a long way since independence in training and staffing national research organizations, ministries of agriculture and the private sector. Yet heavy debt loads, the ravages of HIV/AIDS and falling civil service salaries have all conspired to erode many of these early gains (Eicher, 2001). Today, more than ever, ministries of finance need to become more closely allied with ministries of agriculture to ensure a conducive policy environment as well as adequate salary levels and the recurrent funding necessary for sustaining agricultural support institutions. The recurrence of the cassava mosaic virus and the funding-induced ebbs and flows of new germplasm available in maize cultivation systems attest to the need for long-term, sustainably financed agricultural institutions.

To attract the policy and financial support they require, African agriculturalists need to communicate more effectively the successes they have achieved. We were struck in our survey at the evident disconnect between the optimism of the agricultural establishment and the lackluster, lackadaisical attitude of many outsiders -- including many governments and donors as well as the public at large. In responding to our inquiries, several respondents referred our requests to their institutes' communication departments. The forcefulness and cogency of their input was striking. While eschewing Madison Avenue hype, the agricultural establishment more generally can do better at making its case to public and policy makers who control necessary resources for their advance.

Many of the successful case studies identified here point to a sporadic succession of rapid spurts forward, followed by intervals of atrophy or deterioration. Rapidly mutating diseases, changing policy environments, world market conditions and local rainfall all play a role in the surging and ebbing pulsations of agricultural advance. In the future, we intend more in-depth investigations to help pinpoint key factors necessary in sustaining steady upward momentum. What is clear at this stage is that in understanding this highly dynamic environment, African farmers –women and men-- will remain key actors and key informants. Their active participation has proven instrumental in achieving many of the continent's most enduring successes in the past. Their continued

involvement will undoubtedly prove central to building a system of sustainable agricultural advance.

The stakes here are high. Poverty reduction in Africa will simply not occur without a vibrant agricultural sector providing income, employment and affordably priced staple foods. For this reason, the nurturing of a sustainable, growing agriculture constitutes a fundamental thrust around which the battle against African poverty must be waged.

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Annex Table A.1. A Detailed Listing of All Success Nominations

COMMODITY-SPECIFIC

Aquaculture
- integrated aquaculture in Malawi
- fish farming
- shrimp/fish production in Madagascar

Bananas
- introduction and adaptive breeding in Eastern Africa
- banana introduction and improvement
- bananas in Rwanda
- clonal propagation of superior banana genotypes
- development of high-yielding banana varieties
- tissue culture banana technology in Kenya

Beans
- introduction of improved varieties of climbing beans in East Africa, 1990's
- bean/maize packages

Cassava
- biological control of cassava mealybug (6)*
- production growth in cassava (4)
- conqust of the cassava mosaic virus in Uganda (2)
- breeding for cassava mosiac virus resistance
- rainfed cassava production
- new variety adoption

Cocoa
- development in West Africa
- rehabilitation in Ghana
- production in Ivory Coast
- tree crops in West Africa (cocoa)
- sustainable tree crops initiative (cocoa, coffee, cashew)

Coffee
- smallholder coffee in Kilimanjaro Tanzania, 1930-1960
- clonal coffee in Uganda
- coffee breeding in Kenya
- coffee production
- coffee/tea

Cotton
- in Fracophone West Africa (3)
- in West Africa
- in West and Central Africa
- in Madagascar
- cotton/maize zones in Burkina and Mali
- cotton and hybrid maize in French West Africa
- biotechnology cotton in South Africa

Cowpea
- development of dual-purpose (food and fodder) cowpea in Nigeria

Dairy production
- in Kenya
- smallholder dairying in Kenya
- merry-go-round strategy for dairy cattle provision to women's groups in Kenya
- in Kenya and Uganda
- small-scale dairy development in Cameroon
- Kuku dairy pumping scheme in Khartoum North
- small-scale dairying
- development of dairy industry in sub-Saharan Africa

Fruit trees
- domestication of indigenous fruit trees in West and Central Africa

Groundnuts
- ICRISAT introduction of improved varieties of groundnuts in SADC countries, 1980's and 90's

Horticultural and flower exports
- horticultural exports from Kenya (3)

- horticultural and flower exports from East Africa (2)
- horticultural exports (2)
- horticultural growth in Kenya, Zimbabwe and Uganda
- high-value crops (especially flowers) in Kenya and Zimbabwe
- non-traditional agricultural exports (flowers, vegetables) from Zambia
- promotion of greenhouses for horticultural production
- horticultural export response to CFA franc devaluation in West Africa

Livestock
- domestication of livestock
- genetic improvement of livestock
- livestock production (2)
- livestock and poultry in suburban areas
- livestock in West Africa
- Botswana livestock marketing cooperatives
- beef cattle production in Botswana
- expansion of cattle-based production systems
- integrated livestock/crop development in the Eastern Cape, South Africa
- novel approaches to crop-livestock interaction
- planted forages in West Africa
- development of thermostable vaccines
- development veterinary vaccines
- pan African rinderpest control
- rinderpest vaccine

Maize
- introduction of maize into Africa
- diffusion of hybrid maize in Kenya, 1963-1973
- hybrid maize in Kenya and throughout East Africa
- hybrid maize in Kenya
- hybrid maize in East Africa
- hybrid maize production in East and Southern Africa
- smallholder maize in Zimbabwe
- hybrid maize in Zimbabwe and Kenya
- maize-based revolution in Zimbabwe
- drought and low-fertility maize in Southern Africa
- Malawi top-cross semiflint hybrids
- quality protein maize in Ghana
- maize, cassava, soybean production in Nigeria
- corn stemborer control
- maize and rice (2)
- maize production (2)
- hybrid maize (2)
- improved technologies for maize and beans
- adoption of improved technologies for maize

Millet
- introduction of pearl millet SOSAT-C88 in Nigeria in 1998

Oil palm
- production increases in West Africa

Rice
- WARDA's crossing of African and Asian rice
- rice revolution in Office du Niger, Mali
- expansion in Sukumaland, Northern Tanzania
- improved production at high and low altitudes
- rice production in Sub-Saharan Africa
- increased rice production and consumption

Sweet potatoes
- biotech improvements at KARI
- root crops advances (potatoes, sweet potatoes, cassava)

Sugar cane
- smallholder sugar cane production in Swaziland
- small-scale cane growers in South Africa

Tea
- in Kenya (2)
- Kenya Tea Development Authority

Vegetables
- onions and rice in Mali
- miniature vegetables in Swaziland
- development of underutilized vegetables and fruits
- greenhouse vegetables

Wheat
- Russian wheat aphid control in dryland wheat in South Africa

Wool
- wool shearing sheds in Transkei/Ciskei (2)

Yam
- minisett technology

General
- cash crop export growth (2)
- food production and cash crop exports from Francophone West Africa
- Tanzania cereal production
- industrial crop development: tea, coffee, sugarcane

ACTIVITY-SPECIFIC

Agricultural research
- maintenance of crop biodiversity and domestication
- germplasm collection and conservation
- introduction of new varieties (2)
- diffusion of improved varieties
- selection, improvement and use of high-yielding varieties
- biotechnology applications
- biological control of insect pests
- phytopathology for pest control
- breeding of drought-resistant cereals and beans
- improved agricultural technology across a wide range of crops
- improved yields for basic foods such as maize and sorghum
- biological control of water hyacinth in Lake Victoria
- salvinia molesta control in Lake Naivasha
- development of improved varieties (fruit trees, maize, rice)
- improved ability to manage pesticide resistance
- livestock vaccination in the 1970's and 1980's
- introduction of agricultural research

Extension and general support programs
- Farmer Support Program in South Africa (2)
- sustainable, community-oriented development programs in Kenya
- Operation Feed the Nation in Nigeria
- Zimbabwe, agricultural development in Dambos wetlands
- Sasakawa Global 2000 in Uganda
- Global 2000 (Sasakawa)

Input supply
- food security through seed import in Angola
- food security through seed multiplication in Angola
- improved seeds in Uganda
- seed and fertilizer starter packes in Malawi
- development of informal bean seed
- bean seed distribution in Rwanda (via NGOs, churches, clinics, schools)
- improved potato seed availability
- guaranteed minimum return credit program in Kenya, 1960-73
- input credit in Zambia

Irrigation
- irrigated agricultural development in selected river valleys: Gezira Scheme, Sudan; Awash Valley, Ethopia; Wabe Shebele Scheme, Somalia
- Chitora irrigation scheme
- Principe irrigation scheme
- private irrigation promotion in Niger
- Gezira scheme in Sudan
- small-scale irrigation in the Sahel
- shower nurseries in Togo
- general expansion of irrigation

Land access and land use management
- new pastoral code in Mauritania
- village land use management in Ghana
- natural resource management in Mali
- Development Bank of South Africa Farm Equity Schemes

Mechanization

- mechanized rainfed farming in Sudan (2)
- animal traction
- advent of mechanization
- donkey draft power in Zimbabwe

Macro policy reform
- rice production in Mali following the 1994 CFA franc devaluation
- CFA devaluation and resulting export expansion in West Africa
- trade policy reform
- peace in Mozambique

Policy reform in agricultural markets
- policy reform in Mali's rice subsector, from 1981 (2)
- market liberalization and development in Mozambique
- food market reform in East and Southern Africa
- market liberalization in Uganda
- parastatal divestiture in Uganda tea and cotton
- milk price liberalization in Kenya and Ethopia
- cocoa and coffee market liberalization in Cameroon
- new agricultural policies in general

Soil fertility enhancement
- improved fallows in Southern Africa
- improved fallows using nitrogen-fixing trees in West and Central Africa
- improved fallows and rockphosphate applications
- soil fertility recapitalization in Western Kenya
- fallow systems of agriculture
- crop rotations to maintain soil fertility
- mucuna technology to improve soils in Benin
- alley cropping with pigeon pea in Togo
- intercropping
- agroforestry in East and Central Africa
- agroforestry in Southern Africa
- conservation farming in Zambia
- conservation farming in Zimbabwe and Zambia
- introduction of soil conservation techniques
- expanded use of inorganic fertilizers
- minimum tillage cultivation
- Zambezi Valley organic enterprises
- land use and terracing

Others
- large-scale commercial farming in East and Southern Africa
- crop-diversification in Zambia
- solar fruit drying

INSTITUTION BUILDING

Agricultural research institutions
- Kenya Agricultural Research Institute (KARI) (2)
- Tanzania agricultural research system
- Ethiopian agricultural research system
- introduction of socio-economics
- participatory research (2)
- enhanced linkages between research and dissemination
- KEFRI/KARI/ICRAF collaboration
- establishment of ASARECA, SACCAR and CORAF

Farmer groups
- Malawi tobacco farmers' groups
- participatory land management in Tanzania
- Groupements Naam in Burkina Faso
- community-based agricultural production improvement in Togo
- farmer organizations for natural resource management
- farmer associations in Africa
- farmer associations and private service delivery
- women's organizations for vegetable exports

Human capacity building
- agricultural training programs (2)
- capacity building
- advanced training for African nationals in finance, management, business, technical fields

Marketing institutions
- Mali market information system (2)

- market information systems in Mali, Zambia and Mozambique
- price information systems
- outgrower and contract farming in Zambia
- improved communications
- cooperative marketing institutions in Kenya

Other institutions

- Mali agrometeorological information service

COUNTRY SUCCESSES

- Ghana, food production increases, 1983-1999
- Ethiopia's agricultural sector, 1990's
- Ivory Coast in the 1960's and 1970's

* Numbers in parantheses indicate multiple nominations.