

# IMPACT OF UGANDA'S

## NATIONAL AGRICULTURAL ADVISORY SERVICES PROGRAM



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DOI: <http://dx.doi.org/10.2499/9780896291898>

**Library of Congress Cataloging-in-Publication Data**

Impact of Uganda's National Agricultural Advisory Services Program /

Samuel Benin . . . [et al.].

p. cm.—(IFPRI research monograph)

Includes bibliographical references and index.

ISBN 978-0-89629-189-8 (alk. paper)

1. Agricultural extension work—Uganda. 2. Agriculture and state—Uganda.  
3. Rural development—Uganda. I. Benin, S. (Samuel) II. International Food  
Policy Research Institute. III. Series: IFPRI research monograph.

S544.5.U33I47 2012

338.1'86761—dc23

2011032914

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## Foreword

**D**ue to its importance in agricultural and rural development, agricultural extension will continue to play a significant role in stimulating economic growth, reducing poverty, and improving food and nutrition security in Africa. Therefore, African governments must work to increase efforts to provide agricultural advisory services to farmers. But policymakers need to know the impacts of and returns to spending on agricultural extension so that they can make informed decisions on how to increase their efforts.

The authors of this monograph contribute to the growing literature and knowledge on the topic by assessing the impact of Uganda's National Agricultural Advisory Services (NAADS) program on several outcome indicators, including the changes between 2004 and 2007 in (1) the adoption of new crop and livestock enterprises and technologies, (2) crop and livestock productivity, (3) share of marketed agricultural outputs, (4) agricultural income, and (5) food nutrition security. They use a combined matching and panel regression approach, data from two rounds of household surveys, and different estimators and model specifications to address and test the implications of different assumptions underlying different evaluation methods.

The authors find that the NAADS program has helped to strengthen farmers' capacity to potentially demand and manage the delivery of agricultural advisory services that are likely to meet their local production and market conditions. However, the results were mixed on whether participation in the program adequately induced participants to establish new enterprises or to adopt technologies and improved practices leading to increased productivity and commercialization of agriculture or better food and nutrition security outcomes than their nonparticipating counterparts. The authors discuss different programmatic and methodological reasons for the mixed findings, with a paramount factor being their inability to capture in their estimations the separate effects of access to other or non-NAADS extension services.

Although methods of evaluating agricultural extension have been widely studied, the new techniques discussed in this research monograph have generated interest in studying the topic further. Future research will have to account for general equilibrium effects of extension programs and consider costs versus benefits.

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## Acknowledgments

Primary funding support for this study was provided by the Department for International Development (DFID) to support the Uganda Agriculture Sector Expenditure Review as part of the DFID/ World Bank Collaborative Programme of Rural Development and Sustainable Livelihoods. Funding for surveys and fieldwork was provided by the NAADS Secretariat. Additional funding support for data analysis and writing of the report was provided through the Strategic Analysis and Knowledge Support System, which is funded by the U.S. Agency for International Development, the EU, the Canadian International Development Agency, and the World Bank. The authors thank Madhur Gautam, Kristin Davis, and three anonymous reviewers for their comments on earlier versions of the document. They also thank all the farmers who set aside part of their time to participate in the surveys and provided invaluable information for the analyses leading to this report.

## Acronyms and Abbreviations

AE	adult equivalent
AgGDP	agricultural gross domestic product
ATT	average treatment effects on the treated
AU	African Union
BOS	Bureau of Statistics (Uganda)
CBF	community-based facilitators
DFID	Department for International Development
DID	difference-in-differences
GDP	gross domestic product
IFPRI	International Food Policy Research Institute
MAAIF	Ministry of Agriculture, Animal Industries, and Fisheries
MFPED	Ministry of Finance, Planning, and Economic Development
NAADS	National Agricultural Advisory Services
NEPAD	New Partnership for Africa's Development
NGO	nongovernmental organization
OLS	ordinary least squares
PEAP	Poverty Eradication Action Plan
PMA	Plan for Modernization of Agriculture
PSM	propensity score matching
SSA	Sub-Saharan Africa
TDS	technology development site
TLU	tropical livestock unit
UGX	Ugandan shilling

# Currency

Ugandan shilling UGX

## Summary

The importance of agricultural extension in agricultural and rural development is widely known, so it is not surprising that agricultural extension has attracted substantial investment of public resources since the 1950s, when national agricultural advisory services began to be formally established by governments, and has strongly returned to the international development agenda (World Bank 2007a). Due to competing uses of public resources for promoting overall growth and equitable distribution, however, careful reflection of the impacts of and returns to public spending in agricultural advisory services is necessary. This is the aim of this study, which focuses on the NAADS program in Uganda that has been implemented since 2001. The NAADS program, which is a key strategy for implementing the government's poverty reduction and national development plan, was conceived as a move away from the top-down approach that is publicly funded, with services provided by public agents, to a demand-driven approach that is still largely publicly funded but with services provided by the private sector. The program targets the development and use of farmer institutions and in the process seeks to empower them to procure enterprise-based advisory services, manage linkages with marketing partners, and conduct monitoring and evaluation of the advisory services they receive from the private sector (Uganda, NAADS Secretariat 2001). By end of the 2006–07 financial year, the period of the analysis in this study, about UGX 110 billion (in 2000 UGX) had been spent on the program, which had been extended to 545 subcounties (about 83.1 percent of the total subcounties in Uganda at the time) from the initial 24 subcounties in six districts where it had been launched.<sup>1</sup> Furthermore, about 1,622 contracts with private-sector service providers had been signed, more than 40 enterprises had been promoted, and about 40,000 farmer groups and 716,000 farmers (representing about 20 percent of the national farming households) had received services from the program (Uganda, NAADS Secretariat 2007).

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<sup>1</sup>As of August 2011, NAADS had been implemented in 79 districts and 710 subcounties (see [www.naads.or.ug/naads.php](http://www.naads.or.ug/naads.php) for the latest information).

## Methods

Because of the complex ways that many factors influence the relationships between extension inputs and outcomes, the main methodological challenge with estimating the impacts of the NAADS program, as with any other public investment program, lies with attributing change in an outcome indicator of interest to the program. The goal is to establish a reliable control group for the participants in the program (or treatment group) with which to compare changes in the value of the indicator over time. To address these challenges, data from the two rounds of household and farmer group surveys and a combined matching and panel regression technique were used to evaluate the program in terms of several outcome indicators.

The surveys, which generated panel data on 113 farmer groups and 719 households, were based on a stratified sampling approach according to the years in which the program was implemented in the subcounties (2001–02, 2002–03, and 2005–07) and where the program had never been implemented. The phased-in approach of the program presents a natural experiment for assessing the direct and indirect effects of the program based on the extent of likely contamination of nonparticipants in the program with the treatment. First we defined treatment or participation in the program as including direct participants only, that is, those that were members of a NAADS-participating farmer group (labeled  $NAADS_{DIR}$ ). Then we split the nonparticipants or control observations into three groups: those in the same area where the program was implemented who claimed to have benefited indirectly from the program or been in contact with a NAADS service provider ( $NAADS_{NON-1}$ ), those also in the same area where the program was implemented but who did not claim any benefits or contact with a NAADS service provider ( $NAADS_{NON-2}$ ), and those in areas where the program had never been implemented at the time of the surveys ( $NAADS_{NON-3}$ ).

To alleviate the practical difficulties of testing the validity of the assumptions associated with different program evaluation methods, mostly relating to the behavior of the treatment and control groups prior to the treatment or unobservable behavior following treatment, we used a combined matching and panel regression approach in a two-stage weighted procedure. The selection equation or program participation decision is first estimated by probit to obtain the propensity scores, which are then used as weights in a second-stage difference regression or panel estimation of the average treatment effect ( $ATT$ ). This was applied to different outcome indicators, including adoption of new crop and livestock enterprises and technologies, crop and livestock productivity, share of marketed agricultural outputs, agricultural income, and perception of change in food and nutrition security as well as overall wealth. The combined approach also deals with the fundamental problem faced in applying conventional evalu-

ation methods—the lack of overlap in the covariate distributions or common support between the treatment and control observations, or what is usually referred to as comparing apples and oranges. Different model specifications, including different matching techniques, a number of nearest-neighbor matches, different sets of explanatory variables, and correction versus no correction of the sampling characteristics were used to assess the sensitivity of the results. Terms of interaction between the NAADS treatment indicators and several of the explanatory factors, as well as estimation of the panel regressions for separate subcategories of the factors, were used to assess the distributive effects of the program and factors enhancing or mitigating the impacts.

To capture the direct and indirect effects of the program, the *ATTs* were estimated according to  $ATT_{NON-1}$ , based on the subsample of  $NAADS_{DIR}$  and  $NAADS_{NON-1}$ ;  $ATT_{NON-2}$ , based on the subsample of  $NAADS_{DIR}$  and  $NAADS_{NON-2}$ ; and  $ATT_{NON-3}$ , based on the subsample of  $NAADS_{DIR}$  and  $NAADS_{NON-3}$ . Assuming that direct participation in the program confers greater benefits than occasional contact with NAADS service providers or information, we expected  $ATT_{NON-3} > ATT_{NON-2} > ATT_{NON-1}$ . The average direct effect of the program can be measured by  $ATT_{NON-3}$ , whereas the average indirect effect can be measured by the differences in the *ATTs*, that is,  $ATT_{NON-3} - ATT_{NON-2}$  and  $ATT_{NON-3} - ATT_{NON-1}$ .

## Key Findings and Implications

The key findings are presented in terms of the following: the context of agricultural and rural development represented by the sampled subcounties; progress in implementation of the NAADS program in terms of farmer group institutional development and supply of advisory services; determinants of farmers' decision regarding whether or not to participate in the program; and the effect of participation on outcomes, including distribution of the effects and factors enhancing or mitigating the effects.

### Incidence of Rural Public Services in Farming Communities

In general, the availability of various rural public services and service providers (extension services, input supply shops, markets, roads, schools, health centers, etc.) has improved over time in Uganda, especially between 2001 and 2007, in terms of the presence of physical infrastructure as well as farmers' perceptions of their access to the services. Looking at differences across subcounties shows that the availability of and access to services were mixed, although these were generally better in the NAADS subcounties than in the non-NAADS subcounties. Strengthening rural services and infrastructure is important for both agricultural and rural development. One of the commonly cited weaknesses of the PMA, the agricultural development strategy of the

government at the time, was its failure to strengthen other key rural services such as rural financial and marketing services to complement implementation of the NAADS program. Thus efforts to strengthen the provision of rural financial and marketing services through cooperatives, for example, as stated in the government's development strategies (e.g., the Rural Development Strategy, Prosperity for All, and the National Development Plan), if effectively implemented, would be key for overall agricultural and rural development in Uganda.

### **Progress in Implementation of the NAADS Program**

We find that the NAADS program has helped to strengthen the institutional capacity and human resource skills of many farmers to potentially demand and manage the delivery of agricultural advisory services (e.g., enterprises, technologies, practices, and information) that are likely to meet their local production and market conditions. For example, more than 70 percent of the groups in the NAADS subcounties reporting responded positively to questions about their having received training in several areas, including development of a group constitution and bylaws, leadership skills, growth and development, planning, record keeping, and savings mobilization. Individual members' level of participation in farmer groups' activities was high, and a majority (about 90 percent) of the farmer groups found the various areas of training very useful or useful. Furthermore, NAADS service providers, compared to others, were rated very highly by a majority of the groups in terms of the methods they used in the training and their performance.

However, participation in group activities did not always seem to be commensurate with the power such participation is supposed to give farmers to effectively demand advisory services, which can limit farmers' potential in achieving the expected outcomes of the program, because we assume that membership in a NAADS farmer group confers the previously stated benefits on the members of the group, so participation in the program should have a positive impact on outcomes. False farmer expectations of receiving cash funds and inputs rather than knowledge and advice could have played a significant role here. After all, it has not been that long since the supposed credit scheme called *Entandikwa* (meaning capital to start with for the poor) loaned out UGX 9.92 billion but recovered only 4 percent of it (*Sunday Vision* 2006). Farmers' selected enterprises do not always materialize due to interference in the enterprise selection process for different reasons (ITAD 2008). Because the NAADS program is enterprise based and each subcounty has to prioritize three enterprises for which to receive advisory services, it is impractical to meet each farmer's needs even without outside interference or elite capture.

As expected, we found that not all enterprises were promoted by the NAADS program everywhere. The major crops promoted in terms of the number of subcounties in which they were promoted, the number of technology development sites (TDSs) established for them, or the number of farmer groups directly benefiting from the TDSs included bananas, groundnuts, and rice, followed by vanilla and maize. The major livestock and related enterprises involved goats, poultry, and bees, followed by cattle and pigs. Comparing the different types of enterprises, those involving livestock seemed to be more widely favored.

### **Participation in the NAADS Program**

Although the NAADS program is a public investment intervention, farmers first have to decide whether or not to participate directly in the program through membership in a NAADS-participating farmer group through which individual farmers access grants to procure technologies and advisory services from private-sector service providers. In our sample, 9 percent were classified as direct participants in the program ( $NAADS_{DIR}$ ); 36 percent were those in the same area where the program was implemented and claimed to have benefited indirectly from the program ( $NAADS_{NON-1}$ ); 39 percent were those in the area where the program was implemented but did not claim any benefits ( $NAADS_{NON-2}$ ); and the remaining 16 percent were those in areas where the program had never been implemented ( $NAADS_{NON-3}$ ). Regardless of the model specification or control group used in the analysis, we find that household size has a statistically significant negative association with participation, suggesting that the NAADS program may be seen to offer immediate labor-saving technologies, such as pesticides, which reduce the labor needed for weeding, for example. Other factors with consistent sign across different specifications and control groups include sources of income (positive for livestock and non-farm activities and negative for other agriculture) and amount of land owned (negative). Most of the other covariates had different types of influence (sign, magnitude, and statistical significance) across different subgroups, reflecting different behavior of households based on their different endowments and resources to take advantage of the NAADS programs vis-à-vis their different levels of exposure or nonexposure to the program. Interestingly, we find that the longer the NAADS program has been in a subcounty, the lower the likelihood that farmers participate directly in the program, suggesting that farmers may be giving up direct participation with time. This reflects a declining net gain from direct participation. Farmers may be dropping out due to lack of receipt of grants, increasing cost of participation relative to benefits from any grants, or failure of their preferred enterprise(s) to be selected among the three promoted in the subcounty.

## Effects of Participation in the NAADS Program on Outcomes

### ***Access to Advisory Services and Adoption of New Enterprises and Technologies***

We find that farmers participating directly in the NAADS program ( $NAADS_{DIR}$ ) were associated with a greater increase in access to advisory services between 2004 and 2007 than were their nonparticipating counterparts, either those based in the same areas where the program was implemented ( $NAADS_{NON-2}$ ) or those based elsewhere ( $NAADS_{NON-3}$ ). When they are compared to indirect participants ( $NAADS_{NON-1}$ ), however, we find the opposite effect, because indirect participants ( $NAADS_{NON-1}$ ) received many more extension visits in 2004 and 2007. Although in extension there is a move away from individual farm visits toward the farmer group approach used under the NAADS program, the results show that indirect participants, on average, had more exposure to agricultural advisory services than did direct participants at the beginning of implementation of the NAADS program. Direct participation did not have any statistically significant effect on adoption of new crop and livestock enterprises and the improved agricultural technologies and practices considered here, except in the case of recommended planting and spacing practices, where it was associated with greater use, but only when compared with nonparticipation in areas where the program had never been implemented ( $NAADS_{NON-3}$ ).

The lack of statistical significance of the effect of direct participation in the program on adoption of improved agricultural technologies and practices is surprising and inconsistent with our theoretical predictions. But it is not unreasonable. Adoption of these (e.g., improved seeds and livestock breeds, inorganic fertilizers, and pesticides), with the exception of recommended planting and spacing practices, requires farmers to have financial resources and/or credit facilities from which to acquire them. Therefore, the positive impact of the NAADS program on adoption of recommended planting and spacing practices is not surprising, because such practices may require only additional labor at most. The question is whether greater adoption of recommended planting and spacing practices is sufficient to drive the expected changes in subsequent outcome indicators, including increased productivity, commercialization of production, incomes, and welfare.

### ***Crop and Livestock Productivity and Commercialization of Production***

We find that direct participation had a greater average effect on livestock productivity than on crop productivity, which is consistent with the positive impact on the sale of livestock and livestock products, which is estimated to have been an increase of about 8 percent between 2004 and 2007.

### ***Agricultural Revenue, Food and Nutrition Security, and Welfare***

The results related to change in agricultural revenue (i.e., the value of total agricultural output per adult equivalent) are mixed, with some inconsistency with the previous results in the sense that estimated *ATT* based on the subsample of direct participants ( $NAADS_{DIR}$ ) and those located in areas where the program was never implemented ( $NAADS_{NON-3}$ ) was generally not statistically significant, although it was positive. We found that changes in income from different subsectors may be in competition and that they may not add up as one would expect from using the aggregate income measure. Regarding the broader outcome indicators, we find that direct participation in the NAADS program is generally positively associated with an improving situation and negatively associated with a worsening situation, particularly when participating households are compared to  $NAADS_{NON-2}$  and  $NAADS_{NON-3}$  households.

In sum, the evidence, starting with the analysis of whether the NAADS program adequately induced participants to establish new enterprises or to adopt technologies and improved practices more frequently than their non-participating counterparts, seems patchy, with tenuous links, in terms of consistent sign and statistical significance across the different methods and model specifications, to increased productivity and commercialization of agriculture. Our underlying assumption is that participation in the NAADS program confers benefits via material inputs (seeds, livestock, fertilizers, etc.) that will lead to subsequent outcomes. But this assumption is not consistently validated in the results obtained. It is thus difficult to make definitive conclusions regarding the direct and, particularly, the indirect impact of the NAADS program. The same applies to the earlier results published in Benin et al. (2011). With the NAADS program being rolled out to the entire country, it is not easy to see how any momentum gained in the program can be sustained, particularly in providing the material inputs to drive the changes in adoption, productivity, incomes, and welfare that are expected of participants. Between 2001–02 and 2006–07, the NAADS budget expenditure per subcounty declined at an average rate of 11 and 19 percent per year, considering the amount spent at the subnational level and in the whole country, respectively.

### **Distribution of Impacts and Factors Enhancing the Impacts of the Program**

As expected, the impacts of the program were distributed differently across different groups of farmers in terms of gender, age, education, ownership of assets, or location. Similarly, we find that different factors have contributed differently to enhancing or mitigating the effects of the program. The most

striking result, one that is seemingly counterintuitive at first glance, is that the estimated average impact of the program was greater among households located relatively farther away from credit services and markets. This suggests that the NAADS program, by bringing farmers advisory services and grants for acquiring necessary technologies in addition to creating market linkages, has been more effective in areas with poor access to the services and infrastructure needed to support technology adoption and increased commercialization of agricultural production. Where access to such services and infrastructure is good (including in areas closer to all-weather roads), farmers are able to acquire on their own the improved technologies being promoted by the NAADS program as well as related advisory services.

### **Effects of Indirect Participation ( $NAADS_{NON-1}$ ) and Attrition**

The estimated *ATTs* associated with the comparison between the program's direct participants ( $NAADS_{DIR}$ ) and indirect participants ( $NAADS_{NON-1}$ ) were consistently negative for the different outcomes analyzed, suggesting that the impacts of the program on direct participants were not as great as the change observed for indirect participants. This may reflect the better access to various extension services enjoyed by this group. Furthermore, because farmers in the group defined as indirect beneficiaries are not very familiar with the NAADS program, they may have confused NAADS service providers with agents of other programs, leading to an overestimation of NAADS program effects for this group.

Because some households in the 2004 survey had dropped out by the time of the 2007 survey, we analyzed the potential effect of the attrition on the estimated treatment effects. We find that this likely increased the initial values of the outcome indicators against which direct participants in the program have to be evaluated. In other words, assuming that participation confers benefits leading to higher agricultural revenues, if other things remain unchanged, a greater positive impact of the program on the agricultural revenue of participants will be needed to show a significant positive effect when there is attrition compared to when there is no attrition. Therefore, the estimated treatment effects of the program reported earlier are likely to be underestimated, assuming that the models used are specified and estimated correctly.

### **Limitations of the Study and Issues for Further Research**

Although we have tried to capture several important issues that are critical for a reliable program evaluation study, a major limitation here is our inability to capture in our estimations the separate effect of access to other or non-NAADS extension services. Basically, the government's regular exten-

sion service, as well as nongovernmental organizations and others providing agricultural advisory services through special projects, continued to operate in the same areas as the NAADS program and elsewhere. This is likely to cause over attribution of the estimated effects to the NAADS program, particularly where NAADS participants also benefited from other extension services, as was likely the result in Benin et al. (2011).

A useful follow-up to this study will be to look at the costs and benefits of investment in the program and assess the returns to such investment. In doing so, accounting for any general equilibrium effects will be critical. For example, the scaling out of the NAADS program to all parts of the country is likely to affect relative prices and may also require additional taxes to pay back the loan obtained to finance the program. From the production point of view, both effects mitigate the impact of the program, potentially leading to an overestimation of its benefits based on partial equilibrium analysis of the sort done here. However, reduced food prices, which benefit consumers as well as farmers that are net buyers of food, may cancel or outweigh the negative effect on producer surplus, leading to an overall welfare gain. Similarly, strengthening the capacity of farmers and service providers will affect the skill composition of the labor force and service providers, which in turn will likely affect the wage structure and cost of advisory services. An increase in aggregate demand for services would have similar effects on wages and costs. Thus including economic modeling techniques in assessing the returns will prove useful.

In assessing the benefits, one also needs to consider a range of other benefits that the program can be expected to generate, including the improved human resource skills associated with training and strengthening of local institutional capacity. For example, the training in technical and managerial areas that is provided to private service providers, extension staff, subject-matter specialists, and research staff will develop improved skills, which will contribute to productivity improvements not only on the farm but off. Training of village groups, community-based facilitators, farmer contact groups, and farmer forums at the local level will strengthen local institutional capacities and empower farmers to effectively demand advisory services. The improvements in both human resource skills and institutional capacity will generate benefits when used in nonagricultural economic and noneconomic activities as well.



# Introduction

## Background

The importance of agricultural extension in agricultural and rural development is widely known. Thus it is not surprising that agricultural extension has attracted substantial investment of public resources since the 1950s, when national agricultural advisory services began to be formally established by governments (Anderson 2007), and has returned strongly to the international development agenda (World Bank 2007a). In Uganda, agricultural extension is perhaps the most hotly debated subject, particularly following implementation of the National Agricultural Advisory Services (NAADS) program in 2001. The NAADS program, which is a key strategy to implementing the government's poverty reduction and national development plan, was conceived as a move away from the top-down approach, which is publicly funded, with services provided by public agents, to a demand-driven approach, which is largely publicly funded, with services provided by the private sector. The program targets the development and use of farmer institutions and in the process empowers them to procure enterprise-based advisory services, manage linkages with marketing partners, and conduct monitoring and evaluation of the advisory services they receive from the private sector (Uganda, NAADS Secretariat 2001).

By end of the 2006–07 financial year, the program, whose goal is increasing the proportion of market-oriented production, had been extended to 545 subcounties (about 83.1 percent of the total subcounties in Uganda at the time) from the initial 24 subcounties where it was launched. About 1,622 contracts with private-sector service providers had been signed, more than 40 enterprises had been promoted, and about 40,000 farmer groups and 716,000 farmers (representing 20 percent of national farming households) had received services from the program (Uganda, NAADS Secretariat 2007). Implementation of the NAADS program, however, has not been without interference, especially in recent times. In September 2007, for example, the president of Uganda suspended the program, claiming misuse of funds; the program was reinstated in January 2008 (*Sunday Monitor* 2008). Members of

Parliament vehemently opposed the president's move as being contrary to the country's poverty reduction ambitions and called for a thorough evaluation of the program instead (*Monitor* 2007). Donors supporting Uganda's agricultural sector also threatened to suspend disbursement of a committed \$180 million in financing if the government did not rescind its decision and continue with implementation of the program according to the NAADS Act (*East African* 2009). The donors indicated that the president was using the resources set aside for the NAADS program to fund his own Prosperity for All agenda (*East African* 2009). The use of private service providers as opposed to public extension agents in delivering extension services has been a fundamental issue in Uganda and is also the subject of global debate.

With competing uses of public resources for promoting growth, reducing poverty, and achieving equitable distribution of outcomes, whether socially, economically, or politically motivated, careful reflection by governments and development investors of the impacts of and returns to their investments in the NAADS program is necessary. Due to methodological challenges arising from the complex ways that many factors influence the relationship between extension inputs and outcomes, as well as data quality issues, the existing evidence of the impact of and returns to investment in agricultural extension on the effectiveness of agricultural extension in increasing agricultural productivity and incomes and reducing poverty, among other expected outcomes, is often viewed with skepticism among policymakers and development practitioners. One of the most comprehensive reviews of the impacts of agricultural extension worldwide, which is found in a metastudy of more than 700 case studies, shows that although the average economic rates of return to agricultural extension alone and to combined agricultural research and extension are about 85 and 48 percent, respectively, the range of values is rather large: from zero to 636 percent for the former and from -100 to 430 percent for the latter (Alston et al. 2000). Regarding the NAADS program in particular, some initial evaluations, both qualitative and quantitative, have been quite favorable in terms of its effect on increasing the use of improved technologies, marketed output, and the wealth status of farmers receiving services from the program (Nkonya et al. 2005; OPM 2005; Scanagri Consulting Company 2005; Benin et al. 2007). However, some of the previous findings also show that the program does not appear to be successful in promoting improved soil fertility management, raising concern about the sustainability of potential productivity increases (Benin et al. 2007). Because the first phase of the NAADS program (henceforth NAADS Phase I) ended in June 2008, it is important to rigorously assess the outcomes and impacts of the program and evaluate the returns to investments made in the program so far. These are the aims of this study, the results of which would help inform the imple-

mentation of the second phase of the program (henceforth NAADS Phase II), which is already under way (<http://www.naads.or.ug/news.php?id=88>). The results of this study will also be useful for drawing potential lessons for other countries in Sub-Saharan Africa (SSA) and other developing countries that are implementing or planning to implement demand-driven agricultural advisory services. The findings of this study are expected to be useful to policymakers of central and local governments, farmer groups, advisory service providers, donors, and others seeking to improve agricultural extension services in Uganda and elsewhere.

Before we present details of the NAADS program and the specific objectives of this study, it is useful to look at the context of agricultural and rural development in Uganda within which agricultural extension has evolved to the NAADS program that is currently being implemented.

### **Context of Agricultural and Rural Development in Uganda**

For a long time Uganda has experienced strong economic growth. In the 1990s, the country's gross domestic product (GDP) grew steadily by about 7.2 percent per year from a low rate of about 2.4 percent per year in the 1980s (World Bank 2007b). In per capita terms, the economy steadily grew by about 3.8 percent per year from a declining trend of about -1.2 percent per year in the 1980s. The proportion of the population living under the poverty line declined from 56.4 percent in 1992 to 31.1 percent in 2006 (Uganda, BOS 2010). This remarkable turnaround from the depression associated with the political turmoil and economic mismanagement of the 1970s until the mid-1980s has been achieved through sound policies linked to investments and economic liberalization undertaken by the Government of Uganda with support from the donor community and several other development partners. Despite the substantial progress made, several challenges remain in sustaining the momentum by way of increasing productivity; ensuring the sustainable use of natural resources; and further reducing poverty, hunger, and human disease, among others (Uganda, MFPED 2007a). Recently agriculture has not performed as well as the rest of the economy. For example, from 2000 to 2005 agricultural GDP grew by 4.5 percent per year compared to 5.6 percent for the entire economy (World Bank 2007b). Also, although the incidence of poverty has declined, it is still substantially greater in rural rather than urban areas, 34.2 percent and 13.7 percent, respectively (Uganda, BOS 2010).

Since 2000, the Government of Uganda has been implementing the Plan for Modernization of Agriculture (PMA), the broader framework of the NAADS program, as a key policy initiative aimed at reducing poverty to a level below 28 percent by 2014 (Uganda, MAAIF and MFPED 2000; Uganda, MFPED 2004). The PMA, which emphasizes the revitalization of agriculture as an engine

of growth, poverty reduction, and overall development for the economy, is situated within the country's Poverty Eradication Action Plan (PEAP) (Uganda, MFPED 2004) and vision of Prosperity for All (Uganda, MFPED 2007b) and supported by the broader Rural Development Strategy (Uganda, MAAIF 2005).<sup>1</sup> This attempt to use agricultural growth to drive overall economic growth and development in Uganda is not surprising because agriculture is an important mainstay of a large proportion of the population, contributing about one-third to national GDP and one-half of export earnings and employing four-fifths of the working population (World Bank 2007b). In association with the New Partnership for Africa's Development (NEPAD), the Government of Uganda is also in the process of implementing the Comprehensive Africa Agriculture Development Programme, which provides an integrated framework of development priorities aimed at restoring agricultural growth, rural development, and food security (AU/ NEPAD 2003). This, too, is consistent with the PMA, whose overall objective is to enhance production, competitiveness, and incomes.

The PMA has an ambitious agenda of policy and institutional reform and investments in seven intervention areas, including agricultural extension through the NAADS program. The other complementary areas include agricultural research and technology development, rural financial services, rural infrastructure, marketing and agroprocessing, agricultural education, and natural resource management. Nearly a decade after formulation of the PMA, its implementation has been uneven, with substantial progress made in some of the areas (e.g., NAADS and agricultural research and technology development) but only limited progress in others (e.g., agricultural education and environment and natural resources) (OPM 2005). Agricultural extension in Uganda dates back to the early twentieth century and has undergone a number of transformations that can be summarized as regulatory from 1920 to 1956, advisory from 1957 to 1971, dormant from 1972 to 1981, and educational from 1982 to 1997 (Semana 2008). The provision of agricultural extension and other agricultural support services was the responsibility of the central government until 1997, when it was handed over to local governments in accord with the Local Government Act of 1992. The onset of decentralization faced several challenges, chiefly lack of funds and equipment to facilitate the work of extension agents at the local government level (Sserunkuuma and Pender 2001). For example, the proportion of district budgets allocated to agricultural production and marketing in three districts studied by Francis

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<sup>1</sup> The latest PEAP expired in May 2008, and the government has replaced it with a national development plan (Uganda, MFPED 2010).

and James (2003) was 3 percent or less, whereas at the subcounty level the proportions were even smaller. Extension agents surveyed in Tororo district felt that decentralization had negative impacts on their ability to provide extension services (Enyipu, Semana, and Kabuye 2002), which is not surprising considering that many other aspects of the system remained centralized or top down. Thus the NAADS program was born of and rationalized on the basis of deepening decentralization of extension services through a demand-driven, client-oriented, farmer-led system that targets the poor and women and funded by all, including development partners, central and local governments, and farmers (Uganda, NAADS Secretariat 2001).

### **The NAADS Program**

The NAADS program, which started in 2001, was planned as a 25-year program with an initial phase of 7 years that ended in June 2008. The goal of the program is increasing the proportion of market-oriented production by empowering farmers to demand and control agricultural advisory and information services. The objectives (Uganda, MAAIF and MFPED 2000) are as follows:

1. increasing the effectiveness, efficiency, and sustainability (including financing, private-sector participation, farmer responsiveness, deepening decentralization, and gender sensitivity) of the extension delivery service;
2. increasing access to and sustaining knowledge (education), information, and communication among farmers;
3. increasing access to and sustaining effective and efficient productivity-enhancing technologies among farmers;
4. creating and strengthening linkages and coordination within the overall extension services; and
5. aligning extension to government policy, particularly privatization, liberalization, decentralization, and democratization.

The program is implemented according to an institutional framework as defined in the NAADS Act of June 2001. The institutions involved are farmer organizations; local governments; the private sector; nongovernmental organizations (NGOs); a board of directors; the NAADS Secretariat; the Ministry of Finance, Planning, and Economic Development (MFPED); and the Ministry of Agriculture, Animal Industries, and Fisheries (MAAIF). The NAADS Secretariat is responsible for providing technical guidance and operational oversight to implementation of the program and for facilitating outreach and impact. The main principles and activities of the program are meant to be empowering farmers, mainstreaming gender issues, deepening decentralization, and targeting the economically active poor—those with limited physical

and financial assets, skills, and knowledge rather than destitute or large-scale farmers—through farmers' forums based on specific profitable enterprises, which makes the program enterprise based. The issue of empowerment—which, broadly defined, refers more to a process than to an event of increasing the spiritual, political, social, or economic strength of individuals and communities or of making state and social institutions more responsive to individuals and communities (World Bank 2001)—is critical.

The process of empowerment in the NAADS program is supposed to be as follows. When a farmer decides to participate, he or she has to do so through membership in a NAADS-participating farmer group. Each farmer group, together with members of other NAADS-participating groups in the subcounty, first prioritizes three enterprises (which can be a crop, livestock, fishery, or beekeeping activity or a mixture of those) and requests specific technologies and advisory services associated with their preferred enterprises. It also applies for grants to procure those technologies and related advisory services. The information is forwarded to a subcounty farmer forum by which three or four specific enterprises are selected to be supported under the NAADS program for the subcounty. The Secretariat then works with the subcounty to provide the grants and contract and supervise private professional firms to provide specialized services through demonstrations on the field of a member of the farmer group (or host farmer)—the technology development site (TDS). The host farmer is chosen by fellow members of the group. The establishment of the initial TDS is financed from the grant, and proceeds from the TDS become a revolving fund for members. Selected farmers (community-based facilitators, CBFs) are also trained to extend follow-up services. NAADS coordinators at the district and subcounty levels work with farmer forum executives to manage the allocation of service contracts and to monitor and evaluate the performance of the service providers.

The NAADS program was initiated in 2001 as a pilot program in six districts (Arua, Kabale, Kibaale, Mukono, Soroti, and Tororo) and a total of 24 subcounties within the districts. A few districts and subcounties were added each year, primarily to enable them to benefit from learning by doing. By the end of the 2006–07 financial year, the program had been extended to 545 subcounties (representing 83.1 percent of the total subcounties in Uganda at the time). About 1,622 contracts had been signed with private-sector agencies to provide various specialized services for more than 40 enterprises that had been identified. In the process, about 2,516 CBFs had been trained to provide follow-up services, and 40,000 farmer groups and 716,000 farmers (representing 20 percent of the national farming households) had received services from the program (Uganda, NAADS Secretariat 2007).

By the end of the 2006–07 financial year, about UGX 110 billion (in 2000 UGX) had been spent on the program.<sup>2</sup> In terms of fiscal decentralization, spending was initially equal between the Secretariat and the districts and subcounties (or local governments). This was expected, because the Secretariat handled many of the functions (e.g., procurement) on behalf of the districts and subcounties at the beginning of implementation of the program. Over time, however, the bulk of the spending shifted away from the Secretariat toward the districts and subcounties (Figure 1.1) as the districts and subcounties took over their functions and as more districts and subcounties were added to the program. In the 2006–07 financial year, for example, nearly 80 percent of the total budgetary resources for the program was spent at the district and subcounty levels. Also, over time the amount spent per subcounty declined, at an average rate of 11 and 19 percent per year, considering the amount spent at the subnational level and that of the whole country, respectively; although the amount spent per subcounty seems to have stabilized from 2004–05 onward (Figure 1.1). Looking at the sources of funding, development partners contributed the bulk (nearly 80 percent) of the total resources, with the central government, local governments, and farmers contributing the remaining 20 percent (14, 4, and 2 percent, respectively; Figure 1.2).<sup>3</sup>

The development partners involved include the International Development Association (contributing 49.8 percent of the total amount contributed by donors), the International Fund for Agricultural Development (19.3 percent), the EU (18.1 percent), the Netherlands (5.8 percent), Development Cooperation Ireland (3.8 percent), the Danish International Development Agency (2.2 percent), and the Department for International Development (DFID, 0.9 percent).<sup>4</sup>

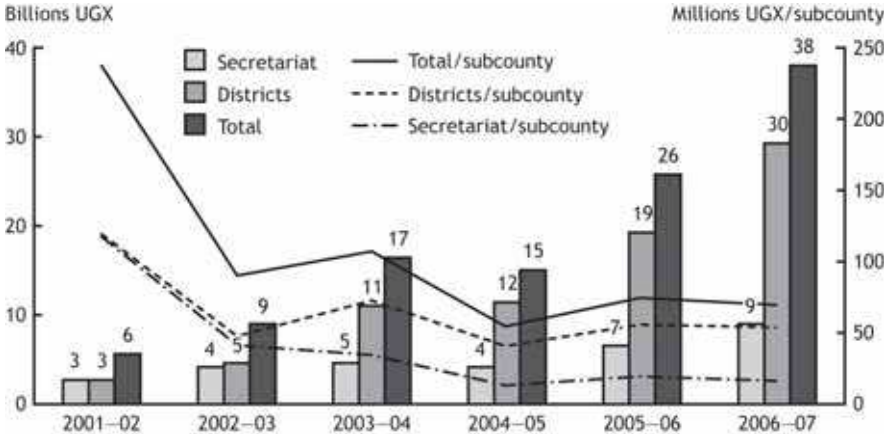
Figure 1.3 shows the specific items on which the funds have been spent, by function. At the beginning of the program, spending was concentrated on management and coordination (e.g., 39 percent in 2001–02), advisory and information services to farmers (35 percent in 2001–02), and farmer institutional development (16 percent in 2001–02). As the program matured, spending on technology development and monitoring and evaluation increased,

<sup>2</sup> This is equivalent to a total of about US\$60.2 million in 2000 constant prices over the same period, or about 0.5 percent and 0.2 percent of agricultural GDP (AgGDP) and GDP per year, respectively, calculated using the official exchange rate, the consumer price index (200 = 100), and GDP data obtained from the *World Development Indicators* (World Bank 2007b).

<sup>3</sup> This does not include the in-kind contribution of CBFs in terms of the opportunity cost of their time spent extending advisory services to farmers in the community.

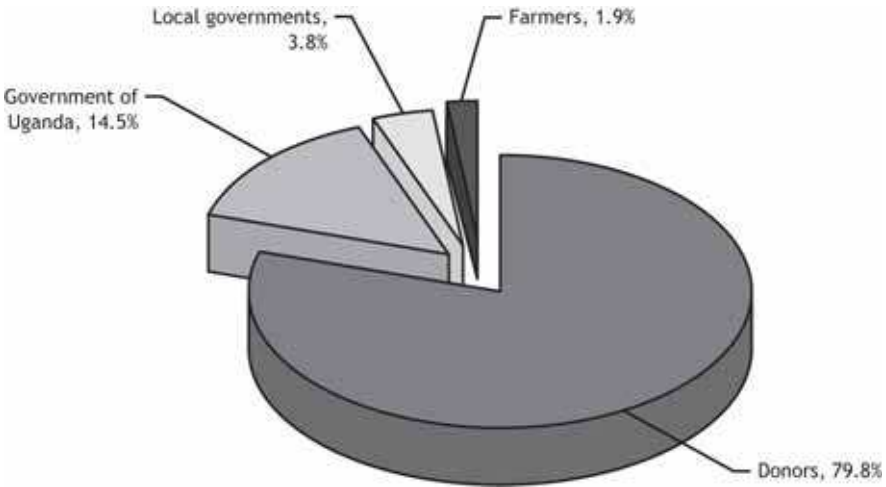
<sup>4</sup> DFID stopped contributing directly to the NAADS program in the 2004/05 financial year but provides nonemarketed budget support to the Government of Uganda.

**Figure 1.1—NAADS expenditure, 2001-02 to 2006-07 (2000 UGX)**



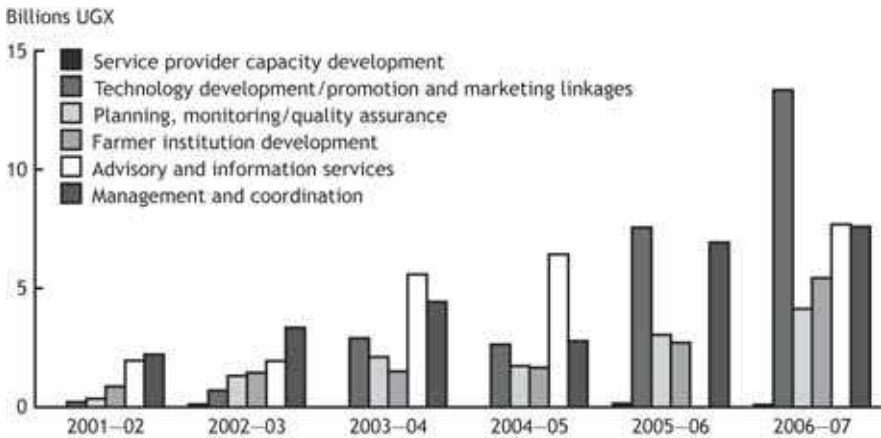
Source: Authors' calculations based on data from NAADS Secretariat.

**Figure 1.2—NAADS expenditure by source, 2001-02 to 2006-07 (percent)**



Source: Authors' calculations based on data from NAADS Secretariat.

**Figure 1.3—NAADS expenditure by activity, 2001–02 to 2006–07 (billions 2000 UGX)**



Source: Authors' calculations based on data from NAADS Secretariat.

with spending on the former attracting the bulk of the allocation since the 2005–06 financial year. In 2006–07, for example, spending on technology development and market development accounted for 35 percent of the total allocation.

### **Aims and Objectives of This Study**

This study, building on previous initial evaluations and surveys of the NAADS program (Scanagri Consulting Company 2005; Benin et al. 2007), has as its overall objective undertaking a rigorous end-of-Phase I evaluation of the NAADS program to analyze and document the outcomes and the direct and indirect impacts of the program. The specific objectives are to

1. assess the incidence of rural public services among farming households;
2. estimate the impacts of the program on various indicators associated with the objectives of the program, including
  - a. farmers' empowerment to organize themselves and demand and manage advisory services,
  - b. farmers' perception of the availability and delivery of advisory services,
  - c. farmers' awareness of and the incidence and intensity of adoption of improved technologies and practices,
  - d. agricultural productivity,
  - e. market participation, and
  - f. income, assets, food and nutrition security, and welfare; and

3. analyze and quantify the contribution of other factors that influence participation in the program and realization of the outcomes, including household demographics and access to other rural public services.

In the next chapter we present the conceptual framework for evaluating the direct and indirect impacts of the NAADS program. This is followed in Chapter 3 by a presentation of the methods used for data collection and evaluation. The results are presented in Chapters 4 and 5, first looking at the landscape within which the NAADS program has been implemented and the delivery of and demand for advisory services in Uganda. This information is followed in Chapter 5 by the effect of the NAADS program on several outcome and impact indicators, as well as an analysis of several factors that have contributed to achievement of the outcomes and impacts. Conclusions, key findings and implications, and issues for further research are presented in Chapter 6.

### Conceptual Framework

**B**ecause many factors affect the performance of agriculture in complex ways, it is critical to first identify the relationships between extension inputs and their impacts. The relationships or the pathways of impact between the NAADS program and agricultural productivity, incomes, and food security are shown in Figure 2.1. By empowering farmers to demand and manage advisory services (represented by *EMP* in the diagram), the NAADS program, represented by the dashed box, is expected to lead to improved supply of advisory services (*AS*) and increased adoption of improved and profitable technologies and practices (*AD*) by farm households, which in turn is expected to lead to improved outcomes including improved natural resource management (*NRM*), reduced unit cost of production (*C*), and increased agricultural productivity (*Q*). Better production outcomes in turn are expected to contribute to increased market participation (*MKT*), higher incomes and greater assets (*INC*), and improved food and nutrition security (*FNS*). By increasing the awareness of improved or profitable enterprises, technologies, and practices (*AW*), which in turn is expected to lead to increased adoption of those technologies and practices, the NAADS program is expected to reinforce the previous linkages.

However, whether farm households actually do adopt the enterprises, technologies, practices, or information being promoted by the program depends on several conditioning factors, including the capacity of service providers (*S*) to provide them as well as the ability of farmers to adopt them. The latter is influenced by their constraints with respect to several factors at the household (*H*) and farm (*F*) levels, including land, labor, capital, other assets, credit, livelihood options, and so forth (Feder, Just, and Zilberman 1985; Feder and Umali 1993). The ability of farmers to adopt the technologies also hinges on availability of the technologies, which is typically shaped by local government and community factors (*LC*) as well as national-level and policy factors (*P*), which are typically associated with political support and budget allocation for the program in particular as well as with overall infrastructure development, promotion of nonfarm employment opportunities, and prices,

among others. For example, availability of off-farm employment opportunities (or off-farm income) can contribute to agricultural income by providing resources to hire labor or to purchase inputs. On the other hand, off-farm employment opportunities may reduce farmers' incentives to invest in agriculture in general (and adoption of NAADS technologies in particular) as they become less dependent on the farmland and as the opportunity costs of their labor and capital are increased by having access to more profitable alternatives (Holden, Shiferaw, and Pender 2001; Nkonya et al. 2004).

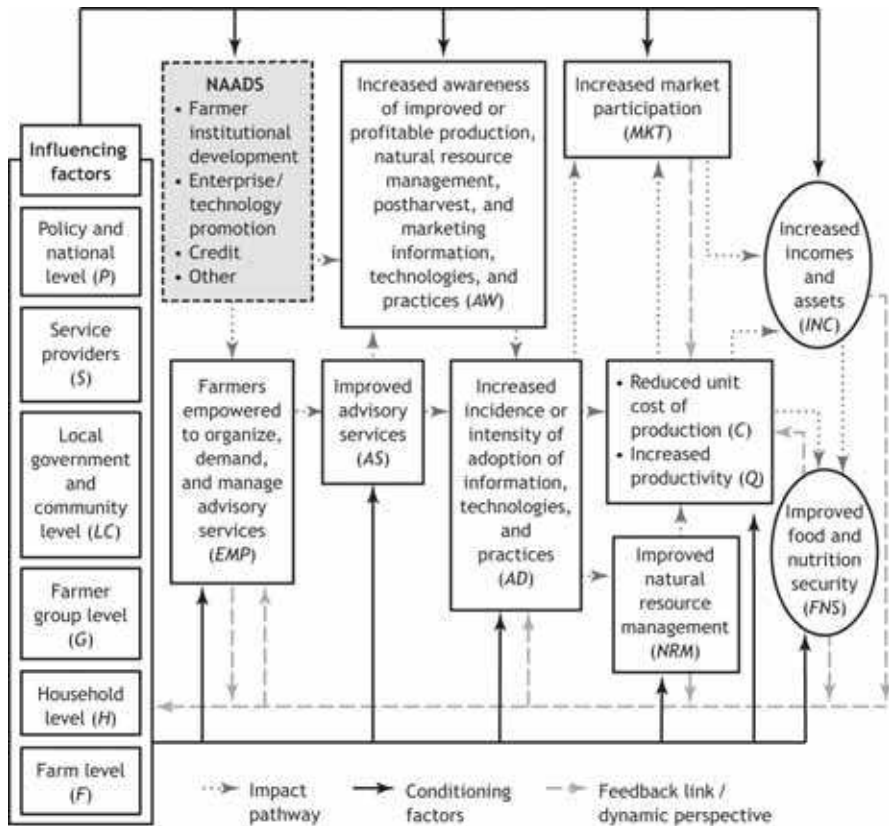
The extent to which such changes result in more or less agricultural productivity, for example, also depends on how well local markets, institutions, and policies function to relax or increase the constraints facing farmers and households. For example, where markets are imperfect, production decisions are not separable from consumption preferences (Singh, Squire, and Strauss 1986; de Janvry, Fafchamps, and Sadoulet 1991), so the preference of certain producer groups ( $G$ ) for certain types of foods, for example, may greatly affect the production system independent of considerations of profitability and comparative advantage. The realization of impacts (e.g., greater agricultural productivity, higher incomes, reduced poverty, improved food and nutrition security) may also be conditioned by factors beyond the household's control.

For example, agricultural production depends on agroecological and biophysical factors. In general, livelihoods may be influenced by many village-level factors ( $LC$ ), such as agricultural potential, access to markets, and population density (Pender, Place, and Ehui 1999). These factors largely determine the comparative advantage of a location by determining the costs and risks of producing different commodities, the costs and constraints to marketing, local commodity and factor prices, and the opportunities for and returns to alternative income-generating activities, both on and off the farm. These factors have generalized village-level effects and manifest themselves through, for example, their impact on village-level prices of commodities or inputs or their impact on farm-household level factors such as average farm size.

Other national-level factors ( $P$ ) such as programs, policies, and institutions may influence the pathways at various points. For example, macroeconomic, trade, and market liberalization policies affect the relative prices of commodities and inputs in general throughout the nation. Although such factors may affect different people differently, they cannot be explicitly controlled for in the empirical estimation of the impacts of the NAADS program because the values of their measures do not vary across the unit of observation, in this case households. On the other hand, national agricultural research policies, for example, may affect the types of technologies that are available and suitable to farmers in a particular agroecological region or profit-

able under certain local market conditions. Similarly, national infrastructure development, land tenure, and credit policies and programs may affect the awareness, opportunities, or constraints of different villages or households differently. Figure 2.1 also shows that there may be important feedback links underlying the relationships between the NAADS program and the outcome indicators. These are represented by the dashed paths. For example, households realizing an increase in productivity and farm output from adoption of NAADS technologies in one season may decide to drop this adoption in the subsequent season if they were unable to sell their produce for a profit due to low prices resulting from increased supply, for example. Political leaders

Figure 2.1—NAADS impact pathways



Source: Authors' illustration of the impact pathways.

Note: Dashed paths indicate feedback links underlying the relationships between the NAADS program and the outcome indicators.

may also decide to increase or reduce the budget allocated to the program depending on the outcomes in previous years.

It is important to note that the conceptual framework is consistent with the design and principles of the NAADS program. For example, the program's principle of targeting certain socioeconomic and demographic groups such as the economically active poor farmers, including women and those with limited physical and financial assets, skills, and knowledge (rather than the destitute or large-scale farmers), is consistent with the hypothesis that the ability of farmers to adopt technologies is influenced by their constraints with respect to capital, other assets, and credit, among others. Similarly, the importance of local comparative advantages is reflected in the program's provision of services that are based on locally identified enterprises and production constraints. The six complementary NAADS investment areas of the PMA (including research and technology development, rural financial services, rural infrastructure, marketing and agroprocessing, agricultural education, and natural resource management) are also consistent with the hypothesis of village-level and other higher-level effects associated with availability of technologies, livelihood opportunities, access to services, and terms of trade, among others.

In the next chapter we present the methods used for data collection and for measuring and estimating the relationship between the NAADS program and empowerment of farmers, demand for and adoption of improved agricultural technologies, crop and livestock productivity, sale of agricultural output, and household agricultural revenue and consumption expenditure.

## Methodology

### Surveys and Data Collection

This study used data from two rounds of farmer group and household surveys conducted during the second quarter of 2004 and the fourth quarter of 2007. The 2004 data served as the baseline on which a stratified sampling is based according to the year when the NAADS program was first implemented in the surveyed subcounty or the year when the treatment was applied: (1) subcounties where the NAADS program was first implemented in 2001–02, hereafter referred to as early NAADS subcounties, (2) subcounties where the program began in 2002–03, hereafter referred to as intermediate NAADS subcounties, (3) subcounties where the program began in between 2005 and 2007, hereafter referred to as late NAADS subcounties, and (4) subcounties where the program had not been implemented at the time of the survey, hereafter referred to as non-NAADS subcounties. The late NAADS stratum was created during the second round of the survey from the non-NAADS subcounties stratum of the first-round survey.<sup>1</sup> This was necessary because the NAADS program had begun operating in some of the areas where they were not operating in 2004, that is, at the time of the first-round or baseline survey. Therefore, new farmer groups and households were also surveyed to increase the sample in the non-NAADS subcounties stratum. This stratification was done to account for the effect of the rollout of the program, which may result in a modified treatment in the intermediate NAADS subcounties and the late NAADS subcounties due to learning from previous treatments in the early NAADS subcounties (supply-side effects), as well as from nonrandom preparedness of the intermediate NAADS subcounties and the late NAADS subcounties prior to receiving the treatment (demand-side effects).

Table 3.1 shows the number of households and farmer groups sampled from each stratum in each of the two survey years. At the outset, it was agreed to

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<sup>1</sup> See Benin et al. (2007) for details on the sampling in the first-round survey.

interview about 400, 300, and 200 households (and 50, 40, and 30 farmer groups) in the early NAADS, intermediate NAADS, and non-NAADS subcounties, respectively. From the early NAADS subcounties stratum, all six districts and 24 corresponding subcounties were selected. In the case of the intermediate NAADS subcounties stratum, four of the nine districts and 18 of the 72 subcounties were sampled. The districts and subcounties from the intermediate and late NAADS subcounties strata, as well as from the non-NAADS subcounties stratum, were purposely sampled in such a way that they had similar agricultural potential and market access as the corresponding districts and subcounties in the early NAADS subcounties stratum.<sup>2</sup> For each of the districts in the early NAADS subcounties stratum, a matching district, that is, one with similar market access and agricultural potential, was selected from the other strata. Following the conceptual framework, this was done to minimize the effect of national-level factors ( $P$ ) and other higher-level conditioning factors that may affect the local conditions and livelihoods of different communities differently and are likely to greatly influence agricultural production, revenue, and other outcomes of interest that are analyzed in this study. From each selected subcounty, two parishes were randomly selected, and from each selected parish one village (LC1) was randomly selected. From each of the selected villages, 6–13 households were randomly selected in proportion to the total number of households within each NAADS stratum. For the farmer group survey, one group was randomly selected from each of the selected villages. Together, 902 households and 116 farmer groups were surveyed in 2004, and 1,200 households and 150 farmer groups were surveyed in 2007, with a panel of 719 households and 110 farmer groups (Table 3.1).

Structured survey instruments were used to collect most of the data using different recall periods depending on the relative magnitude or frequency of households' decisions, with shorter recall periods used for more frequently repeated activities and vice versa.<sup>3</sup> The data collected from the household survey include a variety of variables presented in the conceptual framework that capture the conditioning factors at the farmer group level ( $G$ ), such as membership in farmer organizations or networks; the household level ( $H$ ), including gender, age, education, and size composition of the household; and the farm level ( $F$ ), including farm size and agricultural productive assets.

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<sup>2</sup> Agricultural potential is an abstraction of many factors—including rainfall level and distribution, altitude, soil type and depth, topography, presence of pests and diseases, presence of irrigation, and others—that influence the absolute (as opposed to comparative) advantage of producing agricultural commodities in a particular place. Market access is measured as the potential market integration—estimated as travel time to the nearest five markets, weighted by their population (Wood et al. 1999)—and distance to an all-weather road.

<sup>3</sup> See Benin et al. (2007) for details of the survey instruments and data collection process.

**Table 3.1—Number of districts, subcounties, villages, farmer groups, and households sampled from each stratum, 2001–07**

Survey year, sampling units	Intermediate			Non-NAADS	Total
	Early NAADS (2001–02)	NAADS (2002–03)	Late NAADS (2005–07)		
2004					
Districts	6	4	2	2	14
Subcounties	24	18	4	12	58
Villages	48	36	6	26	116
Farmer groups	48	36	6	26	116
Households	402	300	81	119	902
2007					
Districts	6	4	2	6	18
Subcounties	24	18	4	27	73
Villages	48	36	6	60	150
Farmer groups	48	36	6	60	150
Households	402	300	81	417	1,200
Panel (2004 and 2007)					
Districts	6	4	2	2	14
Subcounties	24	18	4	12	58
Villages	48	36	6	26	116
Farmer groups	48	36	6	20	110
Households	323	202	81	113	719

Source: NAADS-IFPRI 2004 and 2007 household and farmer group surveys.

Notes: The stratification is based on the status of implementation of the program in 2007. The panel related to the late NAADS stratum is due to the treatment of some sampling units within the non-NAADS stratum after the 2004 survey. The total size of the panel of households was 719, less than the expected size of 902 because of attrition. The years in parentheses refer to when the NAADS program was implemented.

Data were also collected on outcome and impact indicators associated with awareness (*AW*) and adoption (*AD*) of profitable enterprises and improved technologies and practices, market participation (*MKT*), crop and livestock productivity (*Q*), incomes (*INC*), and food and nutrition security (*FNS*). The surveys were designed and the data collected in a manner consistent with the conceptual framework. To understand the impact of the NAADS program on adoption of new technologies and enterprises, for example, data on awareness and adoption of new technologies and enterprises in 2000–04 and 2004–07 were collected in the 2004 and 2007 surveys, respectively. The information is differentiated according to service providers associated with the NAADS program and otherwise. The 2004 survey was also used to collect information on the 2000 values of the conditioning factors and outcome indicators to control for the pre-treatment scenario. Details of the actual variables used in the analyses and how they were measured are presented later.

The farmer group survey collected data related mainly to the conditioning factors at the local and community level (*LC*), including access to financial services, roads, and markets; agricultural advisory service providers (*S*); characteristics of the NAADS program (particularly farmer institutional capacity development, type of advisory services received, mechanisms of provision, and beneficiaries) based on the perceptions of farmer groups; and empowerment of farmers to organize to demand and manage advisory services (*EMP*), also based on the perceptions of farmer groups. These data, in addition to the secondary data discussed next, were collected primarily to assess progress toward implementation of the NAADS program.

Secondary data were also collected from the subcounty officials to obtain more information on the conditioning factors at the local and community level (*LC*), including infrastructure development and provision of other public goods and services in the subcounty; implementation of the NAADS program in the subcounty related to farmer institutional development (e.g., type of training and number of farmer groups benefiting), type of services provided, and mechanisms of provision (e.g., number of technology development sites and demonstrations); service providers (*S*), including number of contracts; and budgets and expenditures for the NAADS program and other agricultural sector programs.

### **Estimation and Determinants of Outcomes and Impacts**

The main challenge with estimating the impacts of any investment program such as the NAADS program lies with attributing change in an indicator of interest to the program. Due to methodological challenges arising from the complex and often contradictory ways that many factors influence the relationship between extension inputs and outcomes, as well as data quality issues, the existing evidence of the impact of and returns to investment in agricultural extension is often viewed with skepticism. One of the most comprehensive reviews of the impacts of agricultural extension is found in a metastudy of several case studies: 80 of them on the economic returns to agricultural extension only and 628 on the combined returns of agricultural research and extension, with an average rate of return of 85 and 48 percent, respectively (Alston et al. 2000). The former ranges from zero to 636, the latter from -100 to 430. This wide range of negative to positive rates of return, although positively skewed, has increased the level of skepticism among policymakers and development practitioners on the effectiveness of agricultural extension in increasing agricultural productivity and incomes and reducing poverty, among other expected outcomes. The metastudy by Alston et al. (2000) and reviews by others (e.g., Evenson 2001; Anderson 2007) high-

light concern over data quality, cause-and-effect methodological issues, and quantification of all related costs and benefits. The case of evaluation of the training and visit extension system in Kenya in the 1980s is a typical example; the previously estimated large positive returns (e.g., Bindlish and Evenson 1997) were found to be grossly overestimated with careful modeling of confounding factors, whether static or changing over time, among others (Gautam and Anderson 1999).

In this study we used data from the two rounds of surveys, various impact assessment methods, and different model specifications within the same general method to deal with the concerns just stated and to generate greater confidence in the policy implications of the resulting estimates. First we examine the underlying attribution problem and other estimation issues associated with evaluating the NAADS program. Then we present the methods used to address these issues and to estimate the impact of the program.

If we let  $y$  represent the set of outcomes of interest to the study (e.g., agricultural productivity ( $Q$ ) and income ( $INC$ ) as shown in conceptual framework), then the impact of the NAADS program can be measured by the difference between the expected value of  $y$  earned by each farm household  $j$  participating in the program and the expected value of  $y$  the farm household would have received if the farm household had not participated in the program. This difference, which is the impact of the program or simply the impact of treatment, can be measured as the average treatment effect on the treated ( $ATT_j$ ):

$$ATT_j = E[y_{1j} | NAADS_j = 1] - E[y_{0j} | NAADS_j = 1], \quad (3.1)$$

where  $y_{1j}$  is the value of the outcome of farm household  $j$  after participation in the NAADS program and  $y_{0j}$  is the value of the outcome of the same farm household  $j$  if it had not participated in the NAADS program. Unfortunately, we cannot observe the counterfactual, i.e., the value of the outcome of the farm household if the farm household had not participated in the program. In addition, because individual farm households may choose to participate in the program or not participate, those that choose to participate are likely to be different from and benefit more than those that choose not to participate. For example, those that choose not to participate may not have the resources to do so, because participation in the program requires some initial cofunding by participants and adoption of more costly technologies and practices (more will be said on the process of participation later). These differences in behavior, if they influence the outcome, may invalidate the results from simply comparing outcomes by treatment status, possibly even after adjusting for

differences in observed covariates of the outcome. The underlying estimation problem of Equation 3.1 can be represented as a treatment-effects model (Maddala 1983) of the form

$$y_{jt} = \alpha_j + \tau_t + \beta'x_{jt} + \delta NAADS_j + \varepsilon_{jt} \quad (3.2)$$

$$NAADS_j^* = \gamma'w_j + \mu_j$$

$$NAADS_j = \begin{cases} 1 & \text{if } NAADS_j^* > 0 \\ 0 & \text{otherwise} \end{cases}, \quad (3.3)$$

where  $NAADS_j^*$  is a latent unobserved variable whose counterpart,  $NAADS_j$ , is observed in dichotomous form only;  $x_j$  and  $w_j$  are the vectors of explanatory variables affecting the outcome and the decision to participate in the NAADS program, respectively;<sup>4</sup>  $NAADS_j = 1$  and  $NAADS_j = 0$  represent participation and nonparticipation in the program, respectively;  $\alpha$  and  $\tau$  capture the unobserved individual specific effect and time  $t$  specific effect, respectively;  $\beta$  and  $\gamma$  are the vectors of parameters measuring the relationships between the dependent and independent variables;  $\delta$  measures the relationship between the outcome and the program; and  $\varepsilon$  and  $u$  are the random components of the respective equations with joint normal distribution of means  $(\mu, 0)$  and covariance matrix  $\begin{bmatrix} \sigma_\varepsilon^2 & \sigma_{\varepsilon u} \\ \sigma_{\varepsilon u} & 1 \end{bmatrix}$ .

Because by the design of the NAADS program farm households or farmers have to self-select participation in the program through membership in a NAADS-participating farmer group, estimating the parameters of the model by ordinary least squares (OLS) methods is likely to yield biased results, particularly overestimation. Those who choose to participate may also have other characteristics that lead to better outcomes. A number of methods have thus been proposed or employed, depending on assumptions of mainly the reliability of the explanatory variables  $w_j$  as a predictor (or instrument) of the participation decision (i.e., its correlation with  $y_j$ , conditional on  $x_j$ ); the correlation between the unobserved individual specific effect ( $\alpha_j$ ) and the independent variables  $x_j$ ; and the composition and unobserved characteristics of the two groups over the course of the treatment.<sup>5</sup> A method commonly proposed and employed to estimate the parameters of the model is the instrumental-variables method, which, as the name implies, tries to identify

<sup>4</sup> The global set of explanatory variables was presented in the conceptual framework. The specific variables used in estimating each outcome indicator and how they are measured will be presented later.

<sup>5</sup> See Imbens and Wooldridge (2009) for review of issues and methods in program evaluation.

suitable instruments. Another method is the fixed-effect method from panel data analysis, where the assumption is that unobserved differences between the two groups are constant over time and are correlated with the independent variables  $x_j$ , which are also correlated with the unobserved individual specific effect  $\alpha_j$ . More recent methods, such as experimental and quasi-experimental methods, try to establish alternative scenarios that represent the counterfactual situation by ensuring that the composition of the two groups remains the same over the course of the treatment. Each method has its advantages and disadvantages given the practical difficulties of testing the validity of the assumptions and cost implications and the quantitative requirements, among others, that are associated with using the different methods. In this study we use a combined matching and panel regression approach within a two-stage procedure to estimate the impact of the NAADS program on several outcome indicators. To generate greater confidence in the policy implications of our results, however, we also present results from using some of the other individual methods. We next present the individual methods to set the context, followed by our combined matching and panel regression approach.

**Difference-in-Differences Method**

Assuming that the outcome indicator of interest was growing or changing at the same rate between the treatment group and the control group prior to the treatment, the difference-in-differences (DID) or double differencing method, which measures the average gain or change in the outcome  $y$  over time in the treatment group less the average gain or change in the outcome  $y$  over time in the control group, can be used (Ravallion 2008). Albeit simple, this method removes biases in the comparison between the two groups that may be due to permanent differences between the two groups (e.g., location effect), as well as biases from comparison over time in the treatment group that may be due to time trends unrelated to the treatment. The impact of the NAADS program using this method can be obtained by estimating a difference equation of Equation 3.2 by OLS methods simply without the covariates,  $x_j$ , as follows:

$$\Delta y_j = \hat{\alpha} + \hat{\delta}_{DID} NAADS_j + y_{j_{t0}} + e_j, \tag{3.4}$$

where  $\Delta y_j = y_{t1} - y_{t0}$ , and  $y_{t0}$  and  $y_{t1}$  are the outcomes in the initial and later periods, respectively. The method can be extended to include the covariates,  $x_j$ , as shown in Equation 3.5:

$$\Delta y_j = \hat{\alpha} + \hat{\beta}'_{DIDT} \Delta x_j + \hat{\delta}_{DIDT} NAADS_j + y_{j_{t0}} + e_j. \tag{3.5}$$

With the DID method, possible serial correlation (i.e.,  $\text{cov}(\varepsilon_t, \varepsilon_{t-1}) \neq 0$ ) is not considered. Although we do not have historical data on the outcome indicators prior to treatment to test the validity of the underlying assumption, we minimize the effects of violating the assumption by estimating Equations 3.4 and 3.5 using a matched sample of the treatment and control groups (discussed in the next two subsections). In general, the DID method, especially the specification without the covariates, is one that many policymakers can identify with, and the results can be used as a basis to compare the results obtained using other more complex methods.

### **Propensity Score Matching Method**

The fundamental problem in applying the DID and other conventional evaluation methods is lack of overlap in the covariate distributions or common support between the treatment and control observations (Imbens and Wooldridge 2009). This problem is what is usually referred to as comparing apples and oranges. The propensity score matching (PSM) method, which is a quasi-experimental method now commonly used in program evaluation, tries to address this problem by selecting program participants (treatments) and non-participants (controls) that are as similar as possible in terms of pre-treatment observable characteristics that are expected to affect the decision and extent of participation in the program as well as the outcomes due to participation.<sup>6</sup> The difference in outcomes between the two matched groups can be interpreted as the impact of the program on the participants (Smith and Todd 2005). In practice, the PSM method matches subgroups of program participants with comparable subgroups of nonparticipants using a propensity score, which is the estimated conditional probability of participation in the program.<sup>7</sup> In this case, only participants who have comparable propensity scores or have matches are used in the estimation. Those who do not have comparable propensity scores or have no matches are dropped prior to the estimation. After selecting the comparable subgroups, the counterfactual of each participant, that is, the value of the outcome if the participant had not participated in the program ( $\hat{y}_{0j} | NAADS_j = 1$ ), is imputed as the average of the observed outcomes of the participant's nonparticipant matches. Assuming  $i = 1, 2, \dots, M$  matches for the  $j$ th observation,

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<sup>6</sup> This method is referred to as a quasiexperimental method because it seeks to mimic the approach of experiments in identifying similar "treatment" and "control" groups. However, because the comparison groups identified in the PSM method are not selected by random assignment, they may differ in unobserved characteristics even though they are matched in terms of observable characteristics. See Imbens and Wooldridge (2009) for a review.

<sup>7</sup> See Becker and Ichino (2002) on how to implement the PSM method.

$$\hat{y}_{0j} = \begin{cases} y_j, & NAADS_j = 0 \\ \frac{1}{M} \sum_{j \in \mathcal{S}_M(i)} y_j, & NAADS_j = 1. \end{cases} \quad (3.6)$$

A difference estimator is then used to estimate the impact of the NAADS program, or the *ATT* (i.e.,  $\delta_{PSM}$ ), as follows:

$$\delta_{PSM} = \sum_j w_j (y_{1j} - \hat{y}_{0j}), \quad (3.7)$$

where  $w_j$  is a weight based on propensity scores.

Therefore, the PSM method requires econometric estimation of Equation 3.3 only, using a binary dependent-variable model (probit or logit) to predict the conditional probability of participation in the program or being in the treatment group. In this study we used the probit model. The explanatory variables typically used for computing the propensity scores are those that affect the participation decision or the outcomes. We used the conceptual framework to guide selection of the explanatory variables; a detailed description is presented later. To improve matching, however, it is common practice to try different variables and different transformations of the variables, including logarithms, higher-order terms, and interaction factors (Dehejia and Wahba 2002). The idea is that matching is a nonparametric method of preprocessing data to reduce imbalance between the treated and control groups (Imbens and Wooldridge 2009), so exploring different variables as well as their transformations becomes critical in the estimation of Equation 3.3. We follow these practices and use histograms to check overlap (or common support) in the distribution of the propensity scores between the two groups. We also use the balancing test (Dehejia and Wahba 2002) to select the best matched sample of treatment and comparison observations. The balancing test comprises *t*-tests of equality of means in the treated and control groups both before and after matching and based on a regression of each explanatory variable on the treatment indicator. Before matching this is an unweighted regression on the whole sample, but after matching it is a weighted regression using weights based on the propensity scores of the matched sample. Basically, it is a check of whether and the extent to which any differences that existed between the two groups prior to the matching have been reduced or eliminated in the matched sample.

Because the basic PSM method is based on matching each participant with the nearest nonparticipant only, it can limit any potential gain from matching participants with more than one nonparticipant with similar attributes. Thus we also employed matching with more than one neighbor. Specifically, we consider and report results associated with matching with three and five

nearest neighbors. Increasing the number of matches generally increases the precision of the estimates, although at the cost of increasing bias (Dehejia and Wahba 2002). To better understand the results associated with using different numbers of nearest-neighbor matches, however, we tried matches based on 1–10 nearest neighbors and found that the estimates tended to diverge when a small or very large number of matches are used. Nevertheless, we have more confidence in the findings to the extent that the results (especially the signs and statistical significance of the estimates) are similar across the different matches. We used kernel-matching techniques whereby each treated individual is matched based on a weighted average of all controls that fall within a bandwidth or smoothing parameter used to estimate the kernel density and the weights are inversely proportional to the distance between the propensity scores of the treated and controls (Becker and Ichino 2002). Based on the Epanechnikov kernel-smoothing procedure (Epanechnikov 1969), we used the matching method to estimate the impact of the NAADS program, or the *ATT*, for several outcome and impact indicators as mentioned previously, including frequency of extension visits received, adoption of profitable enterprises and technologies, crop and livestock productivity, market participation, and agricultural revenue per adult equivalent.<sup>8</sup>

Compared to the DID method, the matching estimator also nets out the effects of any observable factors that have fixed (or time-invariant) and additive impact on the outcome indicator. Thus the main difference between the two methods as discussed so far lies with controlling for potential bias due to any unobservable characteristics (similar to omitted variable bias) and differences in observable characteristics between treatment and control observations, which reflects the strength and weakness of using either of the two methods. Basically, although the DID estimator assumes that there is common support between all the treatment and control observations, the matching estimator deals with this problem by using only observations deemed to provide adequate support (but based on the assumption that the participation decision model is correctly specified). On the other hand, although the DID estimator nets out the effect of any time-invariant unobservable factors, the matching estimator depends on the assumption that there is no unobserved heterogeneity in the sense that there is no bias arising from unobserved factors or that the bias arising from unobservable factors remains constant through time.<sup>9</sup> These assumptions can be tested to some extent. For example, the unobserved char-

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<sup>8</sup> We weight the household head, other adults (17 years and older), and children (16 years and younger) by 1.000, 0.924, and 0.595, respectively (based on Appleton et al. 1999), to make welfare comparisons across households of different size and demographic composition.

<sup>9</sup> To the extent that unobserved characteristics are correlated with observed characteristics, however, matching does well in minimizing the bias associated with any unobserved characteristics.

acteristics can be tested with the omitted variable test (Greene 1993), but this is useful only to the extent that potential omitted variables or their proxies are available to be included in the participation decision model. The tests for common support (i.e., histograms of the propensity scores and balancing test) also depend on the participation decision model's being correctly specified and estimated. Careful selection of covariates that include several variables measured at different levels (farm, household, community, and region) can be used to minimize the omitted-variable problem and improve common support. Another limitation with using the matching method is that, unlike the DID estimator shown in Equation 3.5, the contribution of other factors ( $x$ ) to achieving the outcomes and impacts cannot be analyzed. Thus it seems that combining the two methods, the preferred approach used in this study, will yield more consistent estimates of the treatment effect than using either method alone. This issue is taken up next.

**Two-Stage Weighted Regression (or Combined Matching and Panel Regression) Method**

To net out the effect of time-variant factors on the outcome over the period of treatment, a regression method is necessary. Because of the potential correlation between the covariates ( $x_j$ ) and the treatment variable ( $NAADS_j$ ), however, conventional regression methods including instrumental variables may not be sufficient. This problem can be interpreted as a multicollinearity problem the severity of whose consequences increases with increasing differences in the covariate distribution or with decreasing common support between participants and nonparticipants of the program (Imbens and Wooldridge 2009). Given the merits of the matching estimator, particularly in reducing the bias between the two groups, we combine matching and regression in a two-stage estimation procedure (Robins and Rotnitzky 1995; Robins, Rotnitzky, and Zhao 1995; Imbens and Wooldridge 2009). Equation 3.3 is first estimated by probit to obtain the propensity scores, which are then used as weights in a second-stage estimation of Equation 3.2. Basically, we apply a two-stage weighted regression (2SWR) method, using the propensity scores from the matching estimator as weights in the DID estimators as follows:

$$\Delta y_j = \hat{\alpha} + \hat{\delta}_{2SWR} NAADS_j + y_{jt0} + e_j, \tag{3.8}$$

and

$$\Delta y_j = \hat{\alpha} + \hat{\beta}'_{2SWRT} \Delta x_j + \hat{\delta}_{2SWRT} NAADS_j + y_{jt0} + e_j. \tag{3.9}$$

The impact of the NAADS program or the *ATT* is measured by  $\hat{\delta}_{2SWR}$  and  $\hat{\delta}_{2SWRT}$  for the two model specifications, respectively. The weighting can be interpreted as removing the bias due to any correlation between  $x_j$  and  $NAADS_j$

(Imbens and Wooldridge 2009), while the regression isolates the effect of  $x_j$  over time.

In a typical two-stage estimation procedure, it is important to address the identification of the second-stage regression or the endogeneity of the first-stage regression. A procedure commonly used is the imposition of exclusion restrictions in the sense of excluding some of the explanatory variables used in estimating the first-stage probit from the second-stage regression (i.e., having  $x \subset w$  or  $x \neq w$  and  $\text{corr}(w, \varepsilon/x) = 0$ ), which is similar to finding appropriate instruments or predictors for treatment or participation in the NAADS program. In general, nonlinearity of the first-stage probit model, as here, renders exclusion restrictions unnecessary for identification (Wilde 2000). Furthermore, because we apply a fixed-effect or difference estimator in the second-stage regression, the condition is satisfied in the sense that  $\Delta x \neq w$ . However, we still used exclusion restrictions to improve identification of the second-stage regression and tested the validity of the excluded variables using Hansen's (1982) chi-squared test of identification.

A critical feature of this combined estimator is that the sample of treated and comparison observations is restricted to be the same as in the matching estimator. Therefore, the 2SWR is estimated using the propensity scores (as weights) and samples associated with the different matching procedures, i.e., one, three, and five nearest-neighbor matches. The 2SWR estimator was used to estimate the impact of the NAADS program on several outcome indicators mentioned earlier as well as to analyze the contribution of various factors ( $x_j$ ) on the different outcome indicators. Two different types of regressions were employed in the second-stage estimation depending on the type of dependent variable, how it was measured, and whether it was measured in both time periods. For dichotomous variables measured in both 2004 and 2007 (e.g., adoption of new crop and livestock enterprises and adoption of selected crop and livestock technologies and practices), we used the fixed-effects probit; otherwise (e.g., for demand of advisory services measured in 2007 only) we used the random-effects specification. For the other indicators that were measured as continuous variables, including crop and livestock productivity, market participation, and agricultural revenue, we used the first-difference fixed-effect regression.

The conceptual framework presented in Chapter 2 shows that change in some outcome indicators can affect change in other outcome indicators. For example, change in agricultural productivity ( $Q$ ) can cause change in market participation ( $MKT$ ), which together with change in agricultural productivity can cause change in income ( $INC$ ). This means that the issue of simultaneity is important in estimating the structural model for each outcome variable. We avoid this problem by using the reduced-form single-equation approach,

in which the same set of exogenous explanatory variables (i.e., excluding the potential endogenous variables) is used in the estimation for all the outcome variables. This specification eliminates the potential for endogeneity bias associated with the endogenous explanatory variables (e.g., adoption of enterprises and technologies, market participation, and productivity) altogether and allows estimation of the total effect of the included explanatory variables on the outcome variable, which is the direct effect of the included explanatory variable plus the indirect effect via the excluded endogenous variables. To get a sense of these relative effects of participation in the program on the outcomes, however, we also estimate another specification of some of the models in which the endogenous explanatory variables are included, such as (1) adoption of technologies and market participation in the productivity equation, (2) adoption of technologies in the market participation equation, and (3) adoption of technologies and market participation in the income equation. These specifications are not rigorous in the sense that they are not structural equations, so the results should be interpreted lightly. Nevertheless, the results can shed light on the likely impact pathways of the program.

## **Estimating Other Effects**

### ***Estimating Indirect or Spillover Effects***

Similar to any public investment program, the NAADS program has potential spillover effects through information flows, for example. Their measurement poses a challenge, however. In the NAADS program, farmers have to decide whether to participate in the program or not to participate in it. When a farmer decides to participate, he or she has to do so through membership in a NAADS-participating farmer group. Then, together with the members of the group as well as members of other NAADS-participating groups in the sub-county, they request specific technologies and advisory services associated with their preferred enterprises and obtain a grant to procure those technologies and related advisory services. The grant is initially used to finance the establishment of a TDS for demonstrations and training. Proceeds from the TDS become a revolving fund for members. Therefore, the direct impact or benefit of the program is via farmers' access to this grant or revolving fund. However, the TDSs and the CBFs associated with the NAADS program are accessible as sources of knowledge to all farmers, irrespective of a farmer's membership status in a NAADS-participating farmer group. This is the channel through which the indirect impact or benefit of the program is expected to be manifested. We should clarify that during the time of the NAADS program's operation, the government's regular extension service, as

well as NGOs and others providing agricultural advisory services through special projects, operated in the same areas where the NAADS program operated. Because some of these organizations and former government extension workers were occasionally contracted to provide NAADS services, it is possible that they were associated with the NAADS program even when they were operating outside the NAADS framework. Nevertheless, spillovers across program boundaries or communities through information flow among farmers were also possible. This means that defining the control group becomes critical in isolating the direct and indirect effects of the program. The idea of having a group of indirect participants seems laudable, although these could be wrongly classified because of some of the reasons cited, especially because we do not have information on the providers of services to the households in order to make the distinction. Evidence from other studies (e.g., Parkinson 2008; Bukenya 2010) suggests that this group of households was very small or at best had casual interactions with NAADS services providers, especially with the rapid expansion of the NAADS program and the limitations on the time of already overburdened CBFs to serve non-NAADS farmers. In those studies, however, the focus was unfortunately on NAADS members, limiting the studies' ability to provide knowledge of the extent of any benefits received by non-NAADS members. In the Parkinson (2008) study, for example, only 9 nonmembers (called nonjoiners) in one subcounty were interviewed compared to 75 members across three districts. In this study, we have the luxury of a rather large subsample of non-NAADS members to work with and explore the direct and indirect effects by defining and using different sets of controls based on the likely contamination of households with the treatment.

Basically, we defined participation or treatment to include only direct participants in the program, that is, those who were members of a NAADS-participating farmer group (labeled  $NAADS_{DIR}$ ). The rest we defined as non-participants (labeled  $NAADS_{NON}$ ). Then we split them into three groups based on the extent of nonparticipants' likely "contamination" by the program. The first control subgroup was made up of those in the same area where the program was implemented who claimed to have benefited indirectly from the program or been in contact with a NAADS service provider, labeled  $NAADS_{NON-1}$ . The second subgroup was also made up of those in the same area where the program was implemented but who did not claim any benefits or contact with a NAADS service provider (labeled  $NAADS_{NON-2}$ ), and the third subgroup was made up of those in areas where the program had never been implemented at the time of the survey (labeled  $NAADS_{NON-3}$ ). We estimated the  $ATT$ s of the program by estimating the models using data on three subsamples representing the treatment group and each of three subcontrol groups at a time, represented by  $ATT_{NON-1}$  for the subsample of  $NAADS_{DIR}$  and

$NAADS_{NON-1}$ ,  $ATT_{NON-2}$  for the subsample of  $NAADS_{DIR}$  and  $NAADS_{NON-2}$ , and  $ATT_{NON-3}$  for the subsample of  $NAADS_{DIR}$  and  $NAADS_{NON-3}$ .

Given that direct participation in the program with access to grants conferred greater benefits than occasional contact with NAADS service providers or information, and assuming that the models were correctly specified and estimated, we expect  $ATT_{NON-3} > ATT_{NON-2} > ATT_{NON-1}$ . The average direct effect of the program can be measured by  $ATT_{NON-3}$ , while the average indirect effect can be measured by the differences, that is,  $ATT_{NON-3} - ATT_{NON-2}$  and  $ATT_{NON-3} - ATT_{NON-1}$ . The aggregate overall effect of the program is obtained by summing these over their respective populations and then adding them up.

### Enhancing and Mitigating Factors and Distributional Effects

The NAADS program is one of several institutional reforms and investment interventions undertaken in Uganda, especially under the PMA agenda, for overall agricultural and rural development in the country. These include rural financial services, infrastructure, marketing, and education, among others. Thus, besides controlling for the effect of these factors on the outcomes in the estimation framework, it is equally important to assess how and the extent to which they may have enhanced or mitigated the impacts of the NAADS program. By design, the NAADS program also expects to target specific populations, for example, women and economically active poor farmers (i.e., those with limited physical and financial assets, skills, and knowledge) rather than the destitute or large-scale farmers. Thus we can expect the impact of the program to be different in different places or on different socioeconomic groups. For example, it is suggested that the NAADS program's implementation procedures and practices made it vulnerable to elite capture, benefiting the more educated and influential farmers in the community (Parkinson 2008; Bukenya 2010). Examining these effects as well as other distributional effects of the program can be done in two ways: (1) estimating the  $ATT$ s across several categories of variables representing different socioeconomic and demographic groups (including gender, age, education, income, assets) and incidence of or access to different types of other public services (i.e., credit, roads, markets) and (2) estimating the  $ATT$ s associated with interaction terms between the stated variables and the NAADS indicators.

Regarding the first procedure, we estimated the  $ATT$ s using different subsamples of the data based on categories of the explanatory variables using cutoff points commonly used in measuring related development indicators or those affiliated with the NAADS program, with some adjustments upward or downward to ensure that there were enough observations in each subsample for us to carry out the estimations reliably. These were unnecessary for the discrete explanatory variables such as gender, education, and income strat-

egy, for example. Regarding the grouping based on age of the household head, for example, we used 40 years as the cutoff point as opposed to the 30 years used by the NAADS program managers to distinguish the young from adults. One acre was used in the case of access to land, one-third and two-thirds of the range of the value of productive assets was used for defining asset terciles, and 0.5, 5.0, and 10.0 kilometers were used as the cutoff points to define low and high access to all-weather roads, markets, and credit, respectively. Details of all the cutoff points used are given in the relevant tables in which the results are presented. The analysis was carried out using agricultural revenue per adult equivalent as the outcome indicator for the alternative definitions of participation in the NAADS program using the PSM and 2SWR methods.

Estimating the distributional effects in this manner means that, for any subsample, change between 2004 and 2007 values of the particular explanatory variable used in creating the subsample may not also be used in the estimation. This is important for discrete variables such as gender, education, income strategy, and region to avoid the dummy variable trap, especially when the values of the variable have not changed over time. For subsamples based on explanatory continuous variables, it depends on the variation of the variable within the subsample, because limited variation could lead to estimation problems when the affected variable becomes severely correlated with other explanatory variables. To generate greater confidence in our findings, we carried out the estimations both including and excluding the concerned explanatory variable. Another issue is that because the estimation was done for the alternative definitions of treatment, which are in turn based on subsamples of matched direct participants and nonparticipants or indirect participants and nonparticipants, the number of observations (and degrees of freedom) is further reduced. This is particularly the case for subsamples of direct participants and nonparticipants, which are relatively small, so we could not obtain many of the estimates, especially with the matching method estimator. In general, the results regarding the estimations based on smaller subsamples of the data are less reliable to the extent that they are not representative of the alternative states of the indicators. Because the subcounties were purposely selected and households were randomly selected within the subcounties, the results associated with subsamples defined on the basis household-level characteristics would tend to be more reliable.

The second procedure was performed using the 2SWR method by including interaction factors between the NAADS participation variable and many of the other explanatory variables. Due to multicollinearity problems, however, we included only one interaction term at a time instead of multiple interaction terms. Therefore, the results from these analyses are suggestive only,

because the reason for differences across one factor may be differences across some other factor.

## **Explanatory Variables**

### ***Participation Decision***

Because different factors may affect the different outcomes differently, the determinants of the participation decision, from which the propensity scores that are fundamental to the entire analysis are obtained, become particularly important. The choice of explanatory variables was carefully guided by the conceptual framework that was presented in Chapter 2, drawing on the principles and design of the NAADS program as well as the literature on agricultural household models (Singh, Squire, and Strauss 1986; de Janvry, Fafchamps, and Sadoulet 1991), adoption of agricultural and agroforestry technologies (Feder, Just, and Zilberman 1985; Feder and Umali 1993; Pallanayak et al. 2003; Mercer 2004), and willingness to pay for advisory services (Dinar 1996; Holloway and Ehui 2001; Ajayi 2006), among others. The principles of the NAADS program for targeting are based mainly on the concepts of gender, the economically active poor, limited physical and financial assets, limited knowledge and skills, decentralization and farmer groups, locally relevant enterprises, and access to services and infrastructure (deriving from the broader PMA agenda). Thus we included variables that capture these factors in estimating the participation decision, which we associated with the conceptual variables at different levels: household-level (*H*) factors measured by the gender, age, education and size, and main income-generating activity (crops, livestock, etc.) of the household; farm-level (*F*) factors measured by the size of the farm operated and the value of agricultural productive assets; farmer group-level (*G*) factors measured by membership in organizations or networks; and local government- and community-level (*LC*) factors measured by access to infrastructure and services (distance to nearest financial services, roads, and crop and livestock markets and services). The effect of higher-level factors that define the general context of development, including the political economy of service provision, is captured by fixed-effect or time-invariant regional dummy variables representing the four administrative regions of Uganda (i.e., the Central, Eastern, Northern, and Western regions). To some extent, these regional dummies also control for some local government and community effects. The effect of national-level factors (*N*) on the participation decision is not explicitly captured because the measured values of the factors do not vary across the unit of observation, in this case households.

To improve the outcome of this stage of the analysis, that is, using variables that yield the best matched sample, we tried different methods with

the variables, including using different subsets of the variables; logarithmic transformations of continuous variables; squared terms of continuous variables; and interaction terms among some of the variables such as gender, age, education, assets, and access to infrastructure. We also tried inclusion and exclusion of a variable capturing the length of time the NAADS program has been in the subcounty. Trying these different methods contributes to our assessment of the sensitivity of our results to different covariates. In general, it has been found in some studies that results are fairly insensitive to choice of covariates when a combined matching/ regression method is used compared to when either method is used separately (Imbens and Wooldridge 2009).

### ***Outcomes***

The factors previously discussed are also important determinants of the outcome variables, so we use many of them in the second stage of the 2SWR. From the literature cited earlier, we know that household-level factors such as endowments of physical, human, and financial capital, for example, which are important for use of labor, draft power, manure, and credit (where markets for such inputs do not function properly or exist), are important determinants of the profitability of agricultural production. Households' access to public services affects their ability to purchase or hire inputs, whereas land ownership affects the future returns from current practices. The time-invariant regional dummy variables capture slowly changing agroecological and other village-level factors, which are important for defining local comparative advantages and risks of producing different commodities, the costs of and constraints to marketing, local commodity and factor prices, and the opportunities for and returns to alternative income-generating activities, both on and off the farm. Here, too, interaction terms among some of variables such as gender, age, education, assets, and access to infrastructure are important, and they are used to capture the distributional effects of the program.

A conspicuously missing explanatory variable is access to other or non-NAADS extension services. As we explained earlier, the government's regular extension service, as well as NGOs and others providing agricultural advisory services through special projects, operated in the same areas as the NAADS program and elsewhere. We do not have specific information that allows us to capture the separate effects of this operation on the outcomes, both directly on the outcomes themselves and indirectly via the decision to participate in the NAADS program or not. This is likely to cause overattribution of these estimated effects to the NAADS program, particularly where NAADS participants also benefited from other extension services. In Uganda, decentralization of rural service provision has increased the role of NGOs and community-based

organizations in the provision of extension and other agriculture-related services in rural areas. These organizations operate mostly through farmer groups and associations. For example, in their study on Uganda, Jagger and Pender (2003) found that the presence of an organization dealing with agriculture and environment-related issues such as household membership in such an organization is significantly associated with adoption of several agricultural and sustainable land management technologies. Thus by including household membership in other organizations as an explanatory variable in our model specification and estimation, we expect to reduce the overattribution problem, although we realize that the variable does not exhaustively capture variation in individual information solicitation. Jagger and Pender (2003) show that household involvement or membership in such organizations is significantly influenced by several of the factors discussed earlier.

### **Other Estimation Issues and Interpretation of Empirical Results**

Unless otherwise stated, all monetary values were converted to 2000 constant values using the consumer price index as the deflator. This helped us to exclude the influence of inflation and other temporal monetary and fiscal trends. Based on the stratified sampling approach used in the survey data collection, all the sample statistics and estimates associated with the 2SWR estimator were corrected for stratification, clustering, and weighting of sample. We are unaware of how to fully correct for all of these features with the matching methods. With the PSM method, we tried to correct for stratification by first performing the matching within each stratum and then estimated the *ATT* for each stratum using bootstrapping to estimate the standard errors. Then we used a weighted average procedure to obtain the *ATT* for the whole sample by using the average sampling weight for each stratum as the weight. The implication of this on the resulting estimates is that they will approach the true values to the extent that the within-group and across-group variations in the sampling weights are similar within a particular stratum.<sup>10</sup> To assess the sensitivity of the results in correcting for stratification, clustering, and weighting of sample, we estimated the 2SWR without and with performing the correction.

Typically, correction for stratification, clustering, and weighting of sample requires correct calculation of the standard errors of the estimates for reliable statistical inference. All the analyses in this study were carried out

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<sup>10</sup> For further details on these issues with the matching methods, see Leuven and Sanesi (2003) on how to match within strata and obtain the average effects for the whole population and Abadie et al. (2004) on how to handle probability sampling weights in nearest-neighbor matching estimators.

using STATA software (version 11, StataCorp 2008), which calculates the correct standard errors based on the specification used in terms of identifying the strata, cluster, and sampling weights to be used in the estimation. In the data used here, the clusters were the villages and the sampling weights were calculated using parish-level human population data (Uganda, BOS2003). The sample weights are the inverse of the probability of a household's being selected in the sample, which was calculated as (the number of selected parishes divided by the total number of parishes in the subcounty) multiplied by (the number of selected households divided by the total number of households in the parish). Because population data were available only at the parish (not the village) level, random selection of households at the parish level was assumed in the calculation. Due to the nature of the sampling methods used in the surveys, however, the results are representative only of the selected subcounties, because these were purposely selected.

The panel of 719 households reflects the valid number of households with valid observations on the variables of interest in both the 2004 and the 2007 surveys (see Table 3.1). This means that 183 (i.e., 902 – 719) of the initial households were not used: 159 of them were not unobservable in 2007 because the households were unavailable to be interviewed that year due to either relocation or dissolution of the household; 24 were not used due to missing observations on the variables of interest in one year or the other. The former issue presents a potential for attrition bias when the panel data are used. We tested for the potential attrition bias in two ways. First, we used a simple student *t*-test to analyze differences in the mean values of the relevant variables measured in the initial period (i.e., 2004 data) between the panel observations (719) and the attritor observations (159). This was done separately for the participants and the different subgroups of nonparticipants. Then we applied a commonly used formal test proposed by Beckett, Gould, Lillard, and Welch (1988), the BGLW test, which involves regressing an outcome variable on the explanatory variables (*x*), an attrition dummy, and the attrition dummy interacted with *x* using the 2004 data. An *F*-test of the joint significance of the attrition dummy and the interaction variables is then conducted to determine whether the coefficients from the explanatory variables differ between the attritor households and those remaining in the panel. This is done separately for the participants and the different subgroups of nonparticipants. We present and discuss the test and its results later, in Chapter 5, after details of the variables used in the analysis have been presented.

### **Limitations and Interpretation of Results**

Although our preferred approach for estimating the treatment effect is the 2SWR method given the drawback from using either the DID or the matching

estimator method alone, we still use all three methods to generate more confidence in our findings. Because the methods have different underlying assumptions, however, we naturally do not expect to obtain identical estimates from using the different approaches. The main assumptions underlying the regressions (without the covariates,  $x_j$ ) and matching methods, for example, involve (observable) behavior of the treatment and control groups prior to the treatment as well as their (unobservable) behavior following treatment. These assumptions are not testable with the data at hand to determine a priori the direction or magnitude of any expected differences among the different estimates. By controlling for the effect of change in observable characteristics on change in the outcomes, however, we could expect estimates of the program impacts obtained from using the 2SWR method to be conservative (inflationary) to the extent that the change in the observable characteristics is correlated with participation or nonparticipation and contributes positively (or negatively) to the change in outcomes, other factors being equal. For example, in anticipation of participating in the NAADS program, farmers and officials in non-NAADS subcounties may position themselves in a manner that affects their performance in ways different than otherwise would be the case.

Potential differences in the estimates of the program impacts using the different approaches also arise from our inability to fully correct for stratification, clustering, and weighting of the sample with the matching methods compared to the regression estimators. We attempted to correct for only stratification with the matching. Correcting for stratification and clustering treats observations in the same stratum or cluster as having similar unobservable or omitted characteristics, whereas correcting for weighting of the sample causes the contribution of each observation in the average estimate to be weighted according to its representativeness in the overall population or its likelihood of being included in the sample. Assuming correct specification of the models, we would expect the estimated program impact for each treated observation from using the matching, for example, to be conservative (inflationary) to the extent that the sampling weight associated with the treatment is higher (lower) than those of its control matches, because the sampling weight is the inverse of the probability of being included in the sample. The direction of the bias of the estimated average program impact or average treatment effect of the treated (i.e.,  $|ATT_j|$ ), however, is indeterminate a priori.

As the foundation for our analyses, careful modeling and estimation of the participation decision are particularly important to the estimates of the program impacts, direct or indirect and irrespective of the approach used in obtaining the estimates. We have tried to do these carefully by relying on the design features of the NAADS program as well as the theoretical and empirical

literature on the issues addressed here, within the limitations of the data. The aim of the NAADS program is to help strengthen the institutional capacity and human resource skills of farmers to demand and manage the delivery of agricultural advisory services that meet their local production and market conditions. Thus, assuming that participation in the NAADS program confers these benefits on participating farmers backed by access to program grants that allow them to acquire the necessary technologies, participation should lead to greater agricultural productivity and increased incomes, among other benefits, via greater adoption of profitable enterprises and technologies and related practices and information, all other factors remaining the same. On the other hand, participating farmers may be limited in achieving the expected outcomes of the NAADS program to the extent that participation is not commensurate with the empowerment of farmers to effectively demand advisory services. We did not explicitly capture in the estimation the type and quality of services provided or how participants actually used any services received. We assume that the effect of service providers is the same across all households within the jurisdiction of their service provision, which is captured by the variables measured at the subcounty level. The fixed-effect time-invariant regional dummies may also capture some of this effect. A finding of a lack of (significant) impact could also derive from the way we capture the enterprise-based nature of the NAADS program with the variable that measures the main income-generating activity (crops, livestock, etc.) of a household. Ideally, matching could be done for specific enterprises. However, households engage in multiple activities and enterprises, and different enterprises are introduced in different subcounties (more on this in the next chapter), so performing the match enterprise by enterprise results in very few valid observations for reliable estimation.

Based on the design features of the NAADS program, too, we acknowledge that the participation decision (i.e., determinants) could be different for the direct and indirect participants. We tried different combinations of explanatory variables and their transformations in the estimation of both decisions to examine how they are indeed different in affecting the results. Furthermore, we expect the characteristics of the two groups to be different to the extent that the principles of the program were indeed implemented. For example, if the program's principle of targeting the economically active poor—those with limited physical and financial assets, skills, and knowledge rather than destitute or large-scale farmers—was upheld, one could expect the direct participants to have been significantly different in terms of these characteristics prior to implementation of the program when compared to nonparticipants or indirect participants in the program. These characteristics are testable, and our findings show that direct participants in 2004 were on

average poorer and less educated and had fewer physical and financial assets than indirect participants. Compared to nonparticipants, however, direct participants were mostly similar on average. The issue is how these potential and actual differences between the different groups, for example, direct and indirect participants, affect the estimates of the direct and indirect impacts of the program. We control for some of these differences in the versions of the analyses that incorporate covariates such as changes in education, access to credit, and initial output levels. But because the indirect beneficiaries were not closely involved with the program, they may have confused their interactions with NAADS service providers and other programs' agents operating in the same areas, leading to overestimation of the NAADS program's impact with respect to this group. Another issue is that we use 2004 values as measures of the right-hand-side variables used in our participation equation. By 2004, some of the NAADS participants in the sample had already received program benefits, and the values of some of the indicators used (e.g., land owned, productive assets) could have changed compared to what they were at the time those participants selected into the program.

Given the limitations discussed here, we are more confident in our findings to the extent that the results are similar across the different approaches, especially regarding the sign and statistical significance associated with the relevant variables. Using different specifications and subsets of the data within each approach to get at the direct and indirect impacts also gives us more confidence in findings associated with results that are similar by the same criteria. Furthermore, there is credibility to our findings on the extent to which the results conform to those reported in other literature.

## Progress in Implementation of the NAADS Program

The main purpose of this chapter is to examine progress in implementation of the NAADS program as perceived mostly by farmers. Following the conceptual framework, the indicators analyzed include areas of farmer institutional capacity development and empowerment of farmers to organize and demand advisory services (*EMP*); individual participation in farmer group activities (*G*); and type of advisory services received, mechanisms of delivery, and capacity and quality of different service providers (*S*). The local and institutional context within which the NAADS program has been implemented, including local government and community factors (*LC*), which may also capture national-level and policy factors (*P*) that impact local communities differently, are also examined. Unlike the detailed methodology presented in the previous chapter to assess the impacts of the program, the analysis in this chapter is based on simple descriptive statistics of the secondary data obtained from the subcounty offices and the primary data from the farmer group survey on selected indicators compared between subcounties where the NAADS program was implemented (i.e., the NAADS subcounty stratum) and otherwise (i.e., the non-NAADS subcounty stratum). Similar to the definition of participation in the program at the household level, the status of the subcounty in the program was measured in 2007 to avoid switching over or having any subcounty appear in different strata. Similarly, a NAADS subcounty was always a NAADS subcounty and could not switch status, and the same was true for a non-NAADS subcounty. However, because the program was started at different times in different subcounties, we also compare the selected indicators across different subgroups within each NAADS subcounty stratum: early NAADS (where the program started in 2001–02), intermediate NAADS (where the program started in 2002–03), and late NAADS (where the program started after 2003). This is especially done when the primary data obtained from the farmer group survey are being analyzed. Change in the value of the indicators associated with the different survey years is also analyzed in many cases, so the results are interpreted with these complexities in mind. Although the analysis here does not try to assess any causal impacts

of the NAADS program, it advances many of the hypotheses presented in the conceptual framework.

### **Incidence of Rural Public Services in Farming Communities**

It is common knowledge that the impacts of extension in general and of the NAADS program in this case could be more easily enhanced in areas with better access to infrastructure (e.g., roads and markets) and other rural services (e.g., education, health, and water services) than in those with poor or no access. In general, the data show that availability of various services has improved over time since 2001 in terms of physical infrastructure based on secondary data obtained from the subcounty offices (Table 4.1) as well as farmers' own perceptions of their access to various services based on data from the farmer group surveys (Table 4.2).

#### **All Subcounties**

As Table 4.2 shows, the total length of all roads more than doubled between 2001 and 2007, rising from an overall average (i.e., combining NAADS and non-NAADS counties) of 48 kilometers in 2001 to 128 kilometers in 2007.<sup>1</sup> The number of primary schools, health centers, and NGOs engaged in production and marketing activities also increased substantially between the two periods, while the number of input supply shops increased by nearly four times, albeit from a very small number of shops to begin with. The overall number of extension officers increased by about 18 percent between the same time periods, which is marginal when compared to changes in the other services.

Comparing households' access to various services in terms of distance from their residence to the nearest service or infrastructure, access was greatest to social (education and health) services, a water supply, and seasonal roads, averaging up to 3 kilometers from their residence. This was followed by access to crop output markets and livestock slaughterhouses, which averaged 7 kilometers from their residence. Access to financial services (a bank or microfinance institution), crop input markets, other livestock services, and agricultural extension was reported to be the worst, averaging more than 10 kilometers from their residence.

#### **NAADS versus Non-NAADS Subcounties**

Comparing availability of services or access to services in the NAADS versus non-NAADS subcounties stratum, Tables 4.1 and 4.2 show that availability of

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<sup>1</sup> The effect of different-sized subcounties, in terms of area or population, for example, is not taken into account because we did not collect or have such information for all the subcounties to enable us to standardize them.

**Table 4.1—Availability of services by NAADS and non-NAADS subcounty, 2001–07**

Indicator of service	2001				2004				2007			
	Non-NAADS		NAADS		Non-NAADS		NAADS		Non-NAADS		NAADS	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Length (km) of												
All roads	30.48	10.18	57.65	12.02	66.78	20.68	110.77	19.65	99.27	24.61	136.38	21.48
Tarmac roads	0.81	0.49	2.39	0.69	0.81	0.49	2.61	0.70	0.85	0.49	3.26	0.79
Murrum/ gravel roads	13.10	5.07	17.72	4.33	16.81	5.93	18.61	4.71	19.88	6.62	31.50	10.95
Feeder roads	16.57	5.64	37.54	10.64	17.90	5.55	40.71	11.13	34.10	7.26	42.78	11.48
Number of												
Primary schools	4.50	1.21	13.07	3.03	6.21	1.71	14.71	3.15	14.04	1.91	16.49	3.14
Health centers	1.21	0.31	2.46	0.76	2.25	0.68	3.32	0.77	5.08	0.74	4.15	1.05
Input supply shops	0.08	0.06	0.39	0.12	0.25	0.11	0.68	0.17	1.46	0.42	1.24	0.27
Nongovernmental organizations	1.00	0.34	1.68	0.29	1.29	0.35	2.41	0.32	3.00	0.53	2.51	0.36
Extension officers	1.04	0.25	2.10	0.26	1.17	0.23	2.10	0.24	1.96	0.21	2.07	0.24

Source: Authors' calculation based on data from subcounty offices, which were purposely selected, so no correction was necessary for stratification, sampling, and weighting as with the survey data.

Note: SE: standard error.

**Table 4.2—Farmers' perception of distance (km) to nearest infrastructure or service by NAADS and non-NAADS subcounty, 2004 and 2007**

Indicator of service	2004				2007			
	Non-NAADS		NAADS		Non-NAADS		NAADS	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
All-weather roads	4.22	0.72	2.97	0.32	4.15	0.69	2.85	0.31
Seasonal roads	1.01	0.14	0.68	0.09	0.95	0.13	0.72	0.12
Consumer market	1.91	0.17	2.21	0.17	2.02	0.18	2.15	0.16
Crop output market	6.39	0.49	4.70	0.32	5.97	0.44	4.76	0.26
Crop input market	10.82	0.66	11.43	0.67	10.62	0.63	11.49	0.70
Livestock market	14.32	0.97	9.74	0.48	14.01	0.94	9.54	0.49
Livestock slaughterhouse	6.71	0.45	9.01	0.60	6.51	0.43	8.50	0.57
Veterinary drugs/ clinic	9.92	0.49	9.55	0.46	9.92	0.48	9.25	0.44
Livestock disease control facility	12.95	0.72	10.05	0.67	13.11	0.70	9.85	0.65
Primary school	1.63	0.08	2.06	0.16	1.61	0.08	2.07	0.12
Public health center	3.71	0.17	4.74	0.23	3.58	0.17	4.66	0.22
Private health center	3.16	0.27	2.74	0.19	3.07	0.26	2.68	0.18
Major drinking water source	0.83	0.05	0.99	0.11	0.83	0.05	0.93	0.11
Major livestock water source	1.12	0.08	1.35	0.14	1.10	0.07	1.25	0.13
Major fuelwood source	2.64	0.43	1.47	0.19	2.53	0.40	1.31	0.12
Bank or microfinance institution	22.56	0.85	19.11	0.81	22.09	0.83	17.95	0.75
Agricultural extension office	13.33	0.75	7.97	0.44	13.35	0.72	8.06	0.42

Source: NAADS-HFPRI 2007 farmer group survey. No comparative data were collected for 2001.

Note: SE: standard error.

and access to services were mixed, although they were generally better in the NAADS subcounties than in the non-NAADS subcounties.

For example, roads were about 65 percent longer in the NAADS subcounties compared to the non-NAADS subcounties. Also, the numbers of primary schools, health centers, input supply shops, NGOs, and extension officers were higher in the NAADS subcounties compared to the non-NAADS subcounties, ranging from 44 to 180 percentage differences. Only recently, in 2007, were the numbers of health centers, input supply shops, and NGOs higher in the non-NAADS subcounties than in the NAADS subcounties (see Table 4.1). Many of the differences in availability of services observed between the NAADS and non-NAADS subcounties based on secondary data are consistent with the differences in access to services based on farmers' own perception of their access to various services (see Table 4.2). However, farmers in the non-NAADS

subcounties reported better access to crop input markets, livestock slaughterhouses, primary schools, a public health center, and water supply than did those in the NAADS subcounties.

To the extent that these kinds of infrastructure and services enhance the impacts of the NAADS program, the impact or average effect of the NAADS program can be expected to be lower as it rolls out to areas with poorer infrastructure and access to services, which points to the importance of controlling for such factors in assessing the impact of the program. For example, one of the weaknesses of the PMA commonly cited was its failure to strengthen other key rural services such as rural financial and marketing services. Thus efforts to strengthen provision of rural financial and marketing services through cooperatives, for example, as stated in the government's development strategies (e.g., the Rural Development Strategy, Prosperity for All, and the National Development Plan), if effectively implemented, could enhance the impacts of the NAADS program.

To inform the policy debate on such issues, we explore some of the factors that may have made the NAADS program more effective by including terms of interaction between the NAADS treatment variable and some key policy variables (e.g., access to credit and infrastructure). Estimating the distributional effects (see "Enhancing and Mitigating Factors and Distributional Effects" in Chapter 3) also addresses some of this issue by looking at the effectiveness of the program across different regions.

### **Farmer Institutional Development and Empowerment**

Achieving the objective of the NAADS program, establishing an effective and sustainable demand-driven system, depends on how well NAADS-participating farmer groups and their members are empowered to demand and control the delivery of the advisory services. In the NAADS program, developing the institutional capacity of farmer groups begins with identifying existing groups in the communities. Typically these groups have differing objectives, ranging from purely social or mutual support to economic aspects. The identified groups are then supposed to be mentored or trained in several areas, including group dynamics, enterprise selection, and monitoring and evaluation. Community development officers and NGOs operating in the subcounty play leading roles in this process. The trained groups that subscribe to the NAADS principles are expected to register with their respective subcounty office to fully participate in the NAADS program and benefit from NAADS guidance. We now analyze several indicators relating to farmers' institutional capacity development, participation of individual members in farmer group activities, and empowerment of farmers on several fronts. The analysis is based on data from the farmer group surveys.

### **Farmer Institutional Capacity Development**

In the survey farmer groups were asked to reveal the areas in which they had received any form of training or capacity strengthening in areas including rights and responsibilities; group initiation, growth, and development; leadership skills and development; developing a constitution or bylaws; planning (e.g., enterprise selection and identification of constraints); monitoring and evaluation; entrepreneurship skills (farming as a business); sustainable natural resource management; marketing; gender consideration in group development and agricultural production; HIV/ AIDS consideration in group development and agricultural production; record keeping; savings mobilization; income-generating activities; and intergroup farmer associations. Table 4.3 shows the proportion of farmer groups that received training on these, as well as hypothesis tests of differences between non-NAADS and NAADS subcounty cohorts.

The areas in which farmer groups most commonly reported that they had received training included development of a group constitution and bylaws, leadership skills, growth and development, planning, record keeping, and savings mobilization. More than 70 percent of the groups in NAADS subcounties reported receiving this training. Accessing credit and intergroup relations were the areas of training least commonly offered, with fewer than 60 percent of the groups in NAADS subcounties reporting any training activity in these areas. Interestingly, farmer groups in the non-NAADS subcounties stratum also reported having received training in these areas, although the percentage of groups reporting any training activity was lower (about 50 percent).

Comparing the training received across the NAADS cohorts shows that a larger proportion of those in the early NAADS subcounties reported having received training in any of the areas. This may be expected given that it takes time to get things going. To the extent that the training strengthens the skills and institutional capacity of farmers to potentially improve their natural resource management and productivity, for example, the impact of the NAADS program can be expected to be proportionally related to the length of time the program has been implemented in an area, other things remaining the same.

### **Participation in Group Activities**

First we look at the level of participation of individual farmers in group activities including meetings, enterprise selection, TDS establishment, demonstrations, and training, among others, and then we examine key factors perceived by groups as being important for group development and membership, including gender, age, religion, assets, and residence, among others. Participation is used as an indicator of collective action, which is predicated

**Table 4.3—Proportion of farmer groups receiving training between 2004 and 2007, by NAADS cohorts and non-NAADS**

Area of training	Early NAADS (n = 49)		Intermediate NAADS (n = 35)		Late NAADS (n = 3)		All NAADS (n = 87)		Non-NAADS (n = 40)		Paired student <i>t</i> -tests: Non-NAADS versus			
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Early NAADS	Intermediate NAADS	Late NAADS	All NAADS
Rights and responsibilities	0.73	0.06	0.51	0.09	0.67	0.33	0.64	0.05	0.43	0.08	***			**
Group initiation, growth, and development	0.73	0.06	0.71	0.08	0.67	0.33	0.72	0.05	0.48	0.08	**	**		***
Leadership skills and development	0.82	0.06	0.69	0.08	0.67	0.33	0.76	0.05	0.43	0.08	***	**		***
Developing a constitution or bylaws	0.82	0.06	0.74	0.07	0.56	0.67	0.78	0.04	0.53	0.08	**	**		***
Planning	0.80	0.06	0.57	0.08	0.67	0.33	0.70	0.05	0.43	0.08	***			***
Monitoring and evaluation	0.61	0.07	0.51	0.09	0.33	0.33	0.56	0.05	0.33	0.08	***	*		**
Entrepreneurship skills	0.76	0.06	0.63	0.08	0.33	0.33	0.69	0.05	0.43	0.08	***	*		***
Sustainable natural resource management	0.67	0.07	0.60	0.08	0.33	0.33	0.63	0.05	0.43	0.08	**			**
Marketing	0.65	0.07	0.34	0.08	0.33	0.33	0.52	0.05	0.40	0.08	**			
Gender considerations	0.65	0.07	0.60	0.08	0.33	0.33	0.62	0.05	0.45	0.08	**			**
HIV/ AIDS considerations	0.71	0.07	0.51	0.09	0.33	0.33	0.62	0.05	0.45	0.08	**			*
Recordkeeping	0.86	0.05	0.63	0.08	0.33	0.33	0.75	0.05	0.53	0.08	***			**
Savings mobilization	0.76	0.06	0.66	0.08	0.33	0.33	0.70	0.05	0.50	0.08	**			**
Credit access and management	0.55	0.07	0.34	0.08	0.33	0.33	0.46	0.05	0.48	0.08				
Income-generating activities	0.67	0.07	0.43	0.08	0.33	0.33	0.56	0.05	0.40	0.08	***			*
Intergroup farmer associations	0.57	0.07	0.34	0.08	0.33	0.33	0.47	0.05	0.28	0.07	***			**

Source: NAADS-IFPRI 2007 farmer group survey.

Notes: *n*: number of observations; SE: standard error. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance.

on the assumption that all members participate equally and that any outcome from such a participatory process reflects the collective position of farmers, which is supposed to be fundamental to the implementation of the NAADS program. As previously, we analyze these indicators using data from the farmer group surveys, with the mean values of the indicators compared across the different strata of participation and nonparticipation in the NAADS program. Detailed results are reported in Table 4.4.

### ***Participation in Meetings***

We find that the level of participation of farmers in meetings was very high among all farmer groups, that is, in both NAADS-participating and -non-participating groups. However, we find that the level of participation in meetings was relatively higher among the NAADS-nonparticipating groups. Because NAADS-participating groups are formed from existing groups in the communities, this result is somewhat surprising, but it could be a result of including new activities that some members of some groups may feel are not in line with the groups' original goals and objectives. This suggests that efforts to build farmers' capacity to demand advisory services are likely to be more effective when those efforts are targeted toward existing farmer groups with similar or complementary goals and objectives. Thus the strategy of the NAADS program to collaborate with other organizations that have experience in farmer institutional development is aimed in the right direction. The program can focus effort on developing strategies for group viability and sustainability that lead to productive meetings and empowerment of farmers.

### ***Participation in Enterprise Selection, Demonstrations, and Training***

The information here was restricted to NAADS-participating groups only, because it was not relevant to the others. We find decreasing participation of members in enterprise selection with length of time since entry into the program, which could be expected because most of the participating groups in the early NAADS subcounties stratum may have already selected most of the enterprises of their choice, reducing their zeal to further participate in this activity. For newer groups, on the other hand, this is an initial activity on which immediate decisions have to be made in order to access any further support from the NAADS program. These results suggest a shift in interest among the older NAADS-participating groups from basic agronomic and production practices to participation in other activities such as those up the value chain, including marketing and value addition. To this end, operationalization of NAADS' strategy regarding graduation of activities up the entire value chain is critical. However, if the process is to work dynamically

**Table 4.4—Perception of participation in group activities by members since 2004, by NAADS cohorts and non-NAADS (proportion of groups reporting)**

Area of participation, perception of participation	Early NAADS (n = 49)		Intermediate NAADS (n = 35)		Late NAADS (n = 6)		All NAADS (n = 90)		Non-NAADS (n = 46)		Paired student <i>t</i> -tests: Early NAADS versus		
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Intermediate NAADS	Late NAADS	Non- NAADS
Meetings													
Good	0.68	0.07	0.54	0.09	0.50	0.22	0.62	0.05	0.88	0.05			***
Fair	0.12	0.05	0.29	0.08	0.17	0.17	0.19	0.04	0.09	0.04	**		
Poor	0.16	0.05	0.11	0.05	0.17	0.17	0.14	0.04	0.02	0.02			**
Do not participate	0.04	0.03	0.06	0.04	0.17	0.17	0.05	0.02	0.00	0.00			
Enterprise selection													
Good	0.78	0.06	0.63	0.08	0.83	0.17	0.73	0.05	n.a.	n.a.			
Fair	0.10	0.04	0.09	0.05	0.00	0.00	0.09	0.03	n.a.	n.a.			
Poor	0.06	0.03	0.09	0.05	0.00	0.00	0.07	0.03	n.a.	n.a.			
Do not participate	0.06	0.03	0.20	0.07	0.17	0.17	0.12	0.03	n.a.	n.a.	**		
Demonstration/ training													
Good	0.68	0.07	0.37	0.08	0.60	0.24	0.56	0.05	n.a.	n.a.	***		
Fair	0.14	0.05	0.28	0.08	0.00	0.00	0.17	0.04	n.a.	n.a.			
Poor	0.10	0.04	0.11	0.05	0.00	0.00	0.10	0.03	n.a.	n.a.			
Do not participate	0.06	0.03	0.29	0.08	0.20	0.20	0.16	0.04	n.a.	n.a.	***		
Selection of service providers													
Good	0.13	0.05	0.03	0.03	0.17	0.17	0.09	0.03	n.a.	n.a.			
Fair	0.08	0.04	0.03	0.03	0.00	0.00	0.06	0.02	n.a.	n.a.			
Poor	0.04	0.03	0.06	0.04	0.00	0.00	0.07	0.03	n.a.	n.a.			
Do not participate	0.73	0.06	0.83	0.06	0.67	0.21	0.76	0.05	n.a.	n.a.			
Monitoring and evaluation of service providers													
Good	0.17	0.06	0.14	0.06	0.33	0.21	0.17	0.04	n.a.	n.a.			
Fair	0.15	0.05	0.03	0.03	0.00	0.00	0.09	0.03	n.a.	n.a.	*		
Poor	0.04	0.03	0.14	0.06	0.00	0.00	0.08	0.03	n.a.	n.a.			
Do not participate	0.64	0.07	0.69	0.08	0.50	0.22	0.65	0.05	n.a.	n.a.			

Source: NAADS-IFPRI 2007 farmer group survey.

Notes: *n*: number of observations; SE: standard error; n.a.: not applicable. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance.

and sustainably, group thinking around the economics of enterprise selection should be an ongoing process, especially given the changing production environment.

### ***Participation in Selection of Service Providers and in Monitoring and Evaluation***

Participation of members in selection of service providers and in monitoring and evaluation was relatively weak across the board, with more than 65 percent of the groups reporting that members did not participate in these activities (see Table 4.4). Participation was only slightly greater among the older groups (i.e., in the early NAADS subcounties stratum) than among newer groups (i.e., in the intermediate NAADS subcounties stratum). Together with the previously stated findings on participation in meetings and in enterprise selection and training, this suggests that there is a lot of participation but very little power. Basically, farmers are not as empowered as expected to demand and monitor delivery of advisory services, so more effort is needed. If the enterprises selected are not popular with farmers due to political interference, lack of technical expertise in the process, or other factors deemed inappropriate by farmers (ITAD 2008), it is difficult to see how farmers can be empowered.

### ***Requirements for Membership in a Group***

Farmer groups were asked to state whether or not factors such as gender, age, education, religion, income, or membership fees, among others, were required of their members. As Table 4.5 shows, the level of income, gender, educational attainment, and religious association of farmers were not considered important factors in meeting the requirements for membership, because fewer than 15 percent of the groups in any stratum reported that they were important factors. There were some significant differences across some of the strata, however, particularly between NAADS-participating and -nonparticipating groups; a greater proportion of the nonparticipating groups reported that education and gender were important factors. These results imply that income status is not a hindrance to membership in any group, whether NAADS-participating or not, which is important if the NAADS program is to reach poor farmers. Payment of membership fees, age, and location, however, were considered requirements for membership. Nearly all the groups (at least 91 percent) reported that membership fees were required, probably because they are the main source of groups' financial resources. NAADS-participating groups stated that membership fees were necessary to establish a copayment that was required for obtaining a grant under the NAADS program. This is corroborated by the NAADS officials. The average membership fees reported were higher among the NAADS

Table 4.5—Group membership requirements, by sample stratification

Requirement	Early NAADS (n = 49)		Intermediate NAADS (n = 36)		Late NAADS (n = 5)		All NAADS (n = 90)		Non-NAADS (n = 46)		Paired student t-tests: Non-NAADS versus			
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Early NAADS	Intermediate NAADS	Late NAADS	All NAADS
Whether item is required for participation (proportion of groups reporting)														
Membership fee	0.92	0.04	0.92	0.05	1.00	0.00	0.92	0.03	0.91	0.04				
Participation in meetings	0.69	0.07	0.61	0.08	0.40	0.24	0.64	0.05	0.87	0.05	**	***	***	***
Level of income	0.02	0.02	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02				
Physical capital	0.00	0.00	0.03	0.03	0.00	0.00	0.01	0.01	0.04	0.03				
Gender	0.00	0.00	0.03	0.03	0.20	0.20	0.02	0.02	0.13	0.05	***	*		**
Age	0.57	0.07	0.61	0.08	0.40	0.24	0.58	0.05	0.74	0.07	*			*
Location/ residence	0.47	0.07	0.53	0.08	0.40	0.24	0.49	0.05	0.59	0.07				
Level of education	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.04				**
Religion	0.00	0.00	0.03	0.03	0.00	0.00	0.01	0.01	0.02	0.02				
Membership fee (UGX)														
In 2004	1,768	474	11,343	8,254	5,384	2,521	5,745	3,265	2,305	900				
In 2007	4,044	1,146	10,911	5,190	6,255	2,382	6,873	2,148	3,207	1,271				

Source: NAADS-IFPRI 2007 farmer group survey.

Notes: *n*: number of observations; SE: standard error. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance.

groups (Table 4.5), which could hinder participation to the extent that the fees are not affordable by all farmers, especially poorer farmers. Later we test the effect of the factors just described on participation in the NAADS program using the household survey data.

### **Farmer Empowerment**

Within the NAADS program, empowerment is meant to be more of a process than an event of making advisory services more responsive to farmers' needs given their local production and market conditions. The process involves training to develop their capacity across several areas (discussed under "Farmer Institutional Capacity Development") and participatory decisionmaking (discussed under "Participation in Group Activities"). Farmers then have to increasingly be able to demand and as well as manage the delivery of advisory services that meet their needs. To look at this aspect of empowerment, farmer groups were asked to give their opinion as to whether they felt more or less empowered since 2004 in expressing their views to subcounty authorities, including farmers' forums, technical public officers, and political leaders. The results are shown in Table 4.6. Only a few of the groups (fewer than 20 percent) reported that they felt less empowered to express their views to various authorities. The largest proportion of groups reporting an increase in the level of empowerment was among those in the early NAADS subcounties stratum, followed by those in the intermediate NAADS subcounties stratum and those in the non-NAADS subcounties stratum. About one-third of the groups, on average, reported no change in their level of empowerment. Comparing change in empowerment in dealing with the different authorities, the groups felt more empowered since 2004 to express their views to technical public officers, followed by the farmers' forums and then political leaders (Table 4.6). This is encouraging because technical public officers are better placed than the other two groups of subcounty authorities considered here to address farmers' agricultural production problems or other concerns that are not covered under the NAADS program.

To examine the feedback between authorities and farmers, the surveyed groups were also asked to indicate whether they felt there was an increase or reduction since 2004 in the responses they received from the different subcounty authorities to their requests or complaints (Table 4.7). Although the ratings here were less favorable than in the preceding analysis (i.e., in terms of the relative proportion reporting an increase versus those reporting a reduction or no change), most of the farmer groups felt there had been an increase in the responses of authorities to their requests or complaints. Overall, these findings support the earlier hypothesis that participation in group activities has not been commensurate with the power it is supposed to bring

**Table 4.6—Perception of change in empowerment to deal with officials since 2004, by sample stratification (proportion of groups reporting)**

Area of empowerment, perception of change	Early NAADS ( <i>n</i> = 50)		Intermediate NAADS ( <i>n</i> = 36)		Late NAADS ( <i>n</i> = 6)		All NAADS ( <i>n</i> = 92)		Non-NAADS ( <i>n</i> = 54)		Paired student <i>t</i> -tests: Non-NAADS versus			
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Early NAADS	Intermediate NAADS	Late NAADS	All NAADS
Subcounty farmers' forum														
Increased	0.78	0.06	0.74	0.08	1.00	0.00	0.77	0.04	n.a.	n.a.				
No change	0.10	0.04	0.09	0.05	0.00	0.00	0.09	0.03	n.a.	n.a.				
Reduced	0.12	0.05	0.18	0.07	0.00	0.00	0.14	0.04	n.a.	n.a.				
Subcounty political leaders														
Increased	0.76	0.06	0.74	0.07	1.00	0.00	0.77	0.04	0.73	0.06				
No change	0.12	0.05	0.14	0.06	0.00	0.00	0.12	0.03	0.13	0.05				*
Reduced	0.12	0.05	0.11	0.05	0.00	0.00	0.11	0.03	0.13	0.05				
Technical public officers														
Increased	0.61	0.07	0.57	0.08	1.00	0.00	0.61	0.05	0.71	0.07				
No change	0.20	0.06	0.26	0.07	0.00	0.00	0.22	0.04	0.13	0.05				
Reduced	0.18	0.06	0.17	0.06	0.00	0.00	0.17	0.04	0.16	0.05				

Source: NAADS-IFPRI 2007 farmer group survey.

Notes: *n*: number of observations; SE: standard error; n.a.: not applicable. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance.

**Table 4.7—Perception of change in the response of officials to group requests since 2004, by sample stratification (proportion of groups reporting)**

Area of empowerment, perception of change	Early NAADS ( <i>n</i> = 50)		Intermediate NAADS ( <i>n</i> = 36)		Late NAADS ( <i>n</i> = 6)		All NAADS ( <i>n</i> = 92)		Non-NAADS ( <i>n</i> = 54)		Paired student <i>t</i> -tests: Non-NAADS versus			
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Early NAADS	Intermediate NAADS	Late NAADS	All NAADS
Subcounty farmers' forum														
Increased	0.54	0.07	0.41	0.09	0.25	0.25	0.48	0.05	n.a.	n.a.				
No change	0.22	0.06	0.35	0.08	0.25	0.25	0.27	0.05	n.a.	n.a.				
Reduced	0.24	0.06	0.24	0.07	0.50	0.29	0.25	0.05	n.a.	n.a.				
Subcounty political leaders														
Increased	0.54	0.07	0.32	0.08	0.60	0.24	0.46	0.05	0.46	0.07				
No change	0.26	0.06	0.44	0.09	0.20	0.20	0.33	0.05	0.31	0.06				
Reduced	0.20	0.06	0.24	0.07	0.20	0.20	0.21	0.04	0.23	0.06				
Technical public officers														
Increased	0.33	0.07	0.17	0.06	0.50	0.29	0.28	0.05	0.47	0.08		***		***
No change	0.48	0.07	0.49	0.09	0.25	0.25	0.47	0.05	0.33	0.07				
Reduced	0.19	0.06	0.34	0.08	0.25	0.25	0.25	0.05	0.20	0.06				

Source: NAADS-IFPRI 2007 farmer group survey.

Notes: *n*: number of observations; SE: standard error; n.a.: not applicable. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance.

to farmers to demand and monitor the delivery of advisory services that meet their local production and market conditions.

### **Supply of Advisory Services**

Because the NAADS program is enterprise based, one of the first activities of each NAADS-participating farmer group is to prioritize three enterprises (a crop, livestock, fishery, or beekeeping activity or a mixture of them) on which advisory services would be focused. The information from all groups is then forwarded to the subcounty farmers' forum, which selects three specific enterprises to be supported under the NAADS program in the subcounty. Several issues have emerged because only three enterprises can be selected in any given subcounty. For example, ITAD (2008) found evidence of political interference in the process; in some subcounties, some enterprises were believed to have been selected to meet politicians' demands rather than the needs of farmers. With a limit of three enterprises per subcounty with an average of 6,088 households, however, it is inevitable that many farmer groups and farmers may find their preferred enterprise not being included, and consequently they may opt out of the program (see ITAD 2008 for further discussion of these and other issues).<sup>2</sup>

Following selection of the three enterprises, the NAADS program provides technologies for demonstration on the field of a member of a farmer group (or host farmer)—a TDS. The host farmer is chosen by fellow members of the group, and private service providers are contracted to carry out the demonstrations and train farmers at these TDSs. We now look at the enterprises on which advisory services have been given, based on descriptive analyses of the secondary data provided by officials of the subcounties where farmer group and household surveys were conducted.

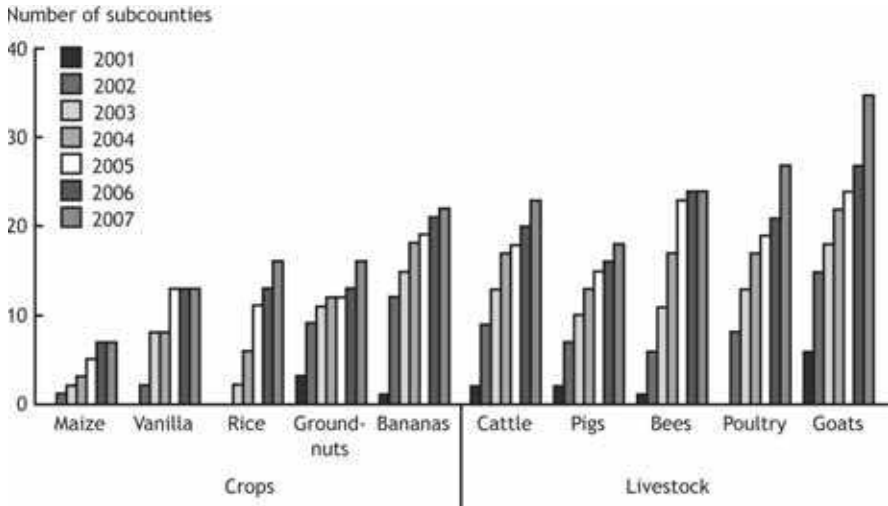
### **Crops**

In all, 36 enterprises (29 crop and 7 noncrop enterprises) were promoted, in terms of the type of TDSs that had been established and the type of demonstrations that were held. Not all of the 36 enterprises were promoted in every subcounty, and none of the enterprises that were promoted were withdrawn. The major crops promoted were bananas and groundnuts, followed by rice, vanilla, and maize (Figure 4.1). It is important to also look at how long a TDS has been in existence, because we expect a greater response to adoption of

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<sup>2</sup> The estimate of 6,088 households is for 2006/07 based on the average number of households in 2002/03 for the surveyed subcounties and with a 3.5 percent growth rate applied (Uganda, BOS 2003).

**Figure 4.1—Promotion of major crop and livestock enterprises (number of subcounties in which promoted), 2001–07**

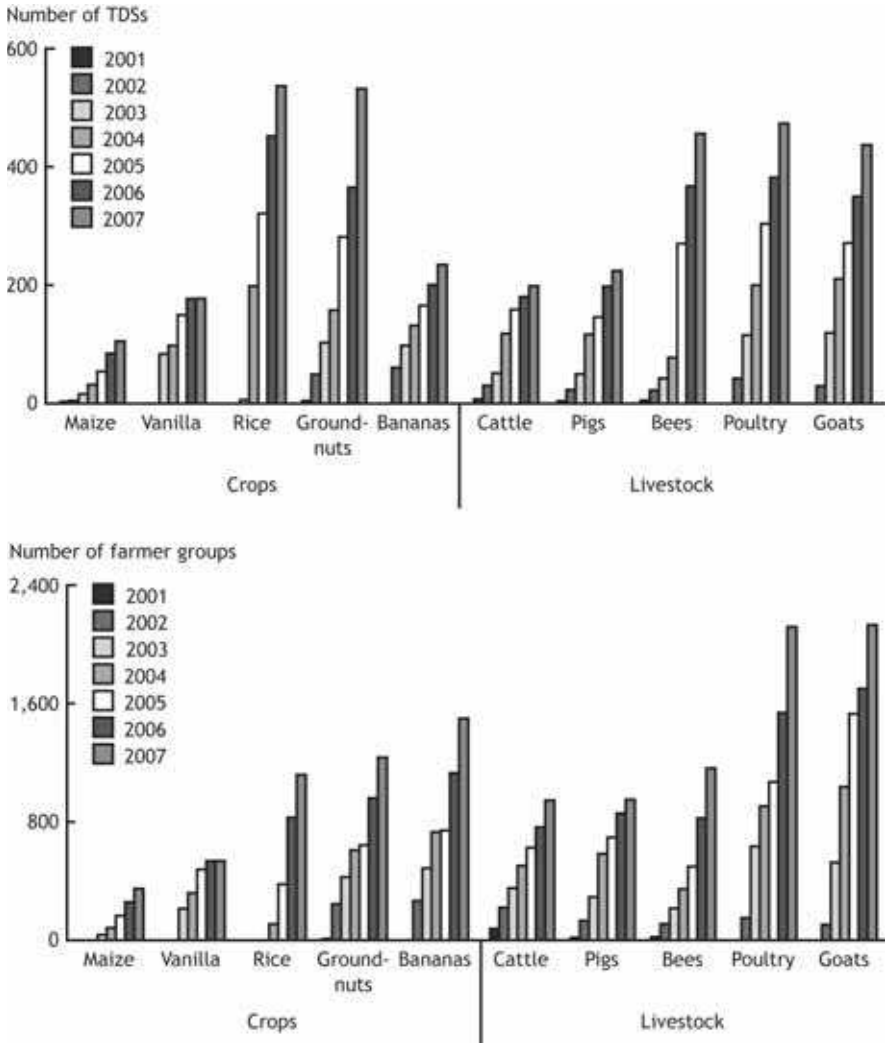


Source: NAADS-IFPRI 2007 subcounty survey.

enterprises that are promoted widely (i.e., in several places) as well as over a long period of time. For example, bananas have been promoted in more than 10 subcounties (or more than 35 percent of the total NAADS subcounties surveyed) since 2002 and had reached 23 subcounties (or 60 percent) by 2007. Comparing rice and groundnuts, although they were both promoted in 16 subcounties (or 43 percent of the total number of subcounties) by 2007, rice was not promoted at all in 2001 and 2002 and was promoted in fewer than 6 subcounties (or 18 percent of the total) until 2005. Groundnuts, on the other hand, have been promoted since 2001 and have been promoted in more than 10 subcounties since 2003, the year when rice started to be promoted.

Looking at what crops have been promoted in terms of the number of TDSs established (Figure 4.2), groundnuts and rice were the most favored crop enterprises, with 540 and 535 TDSs established by 2007, respectively. In terms of the number of registered NAADS farmer groups directly benefiting from the TDSs and demonstrations, bananas, groundnuts, and rice were the most favored crop enterprises, with 1,512, 1,247, and 1,132 farmer groups benefiting from them by 2007, respectively (Figure 4.2). Together, these results suggest that bananas and groundnuts have been the most widely promoted crop enterprises.

**Figure 4.2—Number of technology development sites (TDSs) established for major crop and livestock enterprises and number of farmer groups benefiting, 2001-07**



Source: NAADS-IFPRI 2007 subcounty survey.

### **Livestock and Other Enterprises**

Regarding livestock and other agricultural enterprises, the major ones in terms of the number of subcounties in which they were promoted involved goats (in 35 subcounties by 2007), poultry (27), bees (24), cattle (23), and pigs (18) (see Figure 4.1). In terms of the number of TDSs established, those involving goats, bees, and poultry were the most favored, with 441, 458, and 478 TDSs established, respectively, by 2007. Regarding the number of farmer groups benefiting, goats and poultry were the most favored, with 2,144 and 2,133 farmer groups, respectively, benefiting under each enterprise by 2007. Together, these results suggest that goats and poultry were the most widely promoted livestock enterprises.

Comparing all the enterprises by the various categories (i.e., in terms of the number of subcounties, number of TDSs, and number of groups benefiting), the results presented suggest that livestock were the most widely promoted of the agricultural enterprises.

### **Quality of Capacity Development and Advisory Services**

Ensuring that the technologies and advisory services delivered to farmers are of high quality is very important for the success of the NAADS program. Managers of the NAADS program undertake quality assurance through technical auditing, which is the responsibility of district-based subject-matter specialists who also supervise the delivery of technologies and advisory services to the farmers by the private service providers. We did not obtain information on these activities to assess the quality of advisory services from the program implementer's point of view. In the farmer group survey, however, the groups were asked to express their opinion on the usefulness of the training they had received from the private service providers as well as to rate the service providers on the methods they used and their performance. The results in Table 4.8 show that the majority (about 90 percent) of the farmer groups found the various areas of training or capacity-strengthening activities very useful or useful, with a higher proportion of the groups in the early NAADS subcounties stratum finding them very useful or useful than in the intermediate NAADS subcounties stratum.

### **Summary**

From the evidence presented in this chapter on progress in implementing the NAADS program, together with the finding that NAADS service providers, compared to others (public extension officers and other providers not affiliated with the NAADS program), were rated very high on their methods and performance (Benin et al. 2007), we can conclude that the NAADS program is helping to strengthen the institutional capacity and human resource skills of

**Table 4.8—Perception of usefulness of training received, by sample stratification (proportion of groups reporting)**

Perceived level of usefulness	Early NAADS ( <i>n</i> = 43)		Intermediate NAADS ( <i>n</i> = 28)		Late NAADS ( <i>n</i> = 2)		All NAADS ( <i>n</i> = 73)		Non-NAADS ( <i>n</i> = 54)		Paired student <i>t</i> -tests: Early NAADS versus	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Intermediate NAADS	Late NAADS
Very useful	0.55	0.06	0.48	0.06	0.25	0.25	0.52	0.04	n.a.	n.a.		
Useful	0.36	0.06	0.33	0.06	0.22	0.22	0.34	0.04	n.a.	n.a.		
Somehow useful	0.03	0.01	0.11	0.03	0.53	0.47	0.08	0.02	n.a.	n.a.		
Not useful	0.01	0.00	0.08	0.03	0.08	0.08	0.03	0.01	n.a.	n.a.		

Source: NAADS-IFPRI 2007 farmer group survey.

Notes: *n*: number of observations; SE: standard error; n.a.: not applicable. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance.

many farmers to potentially demand and manage the delivery of agricultural advisory services (e.g., enterprises, technologies, practices, and information) that meet their local production and market conditions. Therefore, assuming that membership in a NAADS farmer group confers these benefits on the members of the group, participation in the program should have a positive impact on the outcome variables. But we have seen that participation in group activities is not always commensurate with the power it is supposed to bring to farmers to effectively demand advisory services, suggesting that participating farmers may be limited in achieving the expected outcomes of the program. Analyzing the association between participation in the program and several outcome variables is the focus of the next chapter.

## Outcomes and Impacts of the NAADS Program

This chapter focuses on the effect of participation in the NAADS program based on several outcome and impact indicators presented in the conceptual framework, including the demand for advisory services, adoption of technologies, crop and livestock productivity, market participation, agricultural revenue, and food and nutrition security. The impact of the program on these indicators was estimated using two different approaches presented earlier: the PSM method and the 2SWR method without and with the covariates,  $x_j$ . The effects of other factors on the outcome and impact indicators were also quantified and analyzed based on the 2SWR estimator when the covariates are included. The panel data of 719 households from the 2004 and 2007 household surveys (or 1,438 total observations) were used for the analysis.

### Treatment, Outcome Variables, and Explanatory Variables

Table 5.1 presents a detailed description and measurement of participation and nonparticipation in the NAADS program or the treatment used in this study. Some 9 percent of the sample were classified as direct participants in the program ( $NAADS_{DIR}$ ), which is about one-half of the 20 percent recorded by officials as beneficiaries of the program (see introduction). The remaining 91 percent made up the general group of nonparticipants, which was subdivided into three. The first subgroup, 36 percent of the total sample, was made up of those in the same area where the program was implemented who claimed to have benefited indirectly from the program ( $NAADS_{NON-1}$ ). The second subgroup, 39 percent, was also made up of those in the area where the program was implemented but did not claim any benefits ( $NAADS_{NON-2}$ ), whereas the third subgroup, 16 percent, was made up of those in areas where the program was never implemented ( $NAADS_{NON-3}$ ).

The program was implemented in 52 percent of the surveyed subcounties in 2001–02, in an additional 28 percent of the subcounties in 2002–03, and in an additional 5 percent of the subcounties after 2003 (see Table 5.1). The variable  $NAADS\_years$  is used in the regressions to capture the effect of change

**Table 5.1—Description of variables and summary statistics on implementation of and participation in the NAADS program**

Variable	Description	Proportion
$NAADS_{DIR}$	Proportion of households that were members of a NAADS-participating farmer group in 2007	0.09
$NAADS_{NON-1}$	Proportion of households that were not members of a NAADS-participating farmer group but accessed or received NAADS-related advisory services	0.36
$NAADS_{NON-2}$	Proportion of households that were not members of a NAADS-participating farmer group nor claimed any benefits but were in the area where the program was implemented	0.39
$NAADS_{NON-3}$	Proportion of households that were located in areas where the program had never been implemented by the time of the survey in 2007	0.16
$NAADS_{years}$	Proportion of subcounties in which the NAADS program was implemented by the indicated year (cf. never implemented)	
$NAADS_{year03-04}$	If after 2003-04	0.05
$NAADS_{year02-03}$	If 2002-03	0.28
$NAADS_{year01-02}$	If 2001-02	0.52

Source: NAADS-IFPRI 2004 and 2007 household surveys.

over time in national-level factors (described later) to the extent that the change affects households differently.

The outcome and impact indicators and other explanatory variables used in the analysis are described in Table 5.2; summary statistics are presented in subsequent sections where the specific variables are analyzed. The variables are presented first for outcome indicators of the NAADS program presented in the conceptual framework, including adoption of technologies and practices (*AD*), crop and livestock productivity (*Q*), agricultural income (*INC*), market participation (*MKT*), and food and nutrition security (*FNS*). These are followed by the explanatory variables used to capture variation at the household level (*H*), measured by gender, age, education, size, and income of the household; at the farm level (*F*), measured by the size of the farm operated and the value of agricultural productive assets; at the farmer group level (*G*), measured by membership in organizations or networks; and at the local government and community level (*LC*), measured by access to infrastructure and services (distance to nearest financial services, roads, and crop and livestock markets and services). The effect of higher-level factors such as agroecology and biophysical and sociocultural factors are measured by fixed-effect or time-invariant regional dummy variables representing the four administrative regions of Uganda (i.e., the Central, Eastern, Northern,

**Table 5.2—Description of outcomes of the NAADS program and explanatory variables**

Variable name <sup>a</sup>	Variable description
Outcome variable	
Adoption of new enterprises and improved technologies and practices ( <i>AD</i> )	
Whether households adopted or used (1 if yes, 0 otherwise)	
New crop enterprises	New crop enterprises
New livestock enterprises	New livestock enterprises
Improved seeds	Improved crop varieties
Spacing	Recommended spacing/ planting practices
Inorganic fertilizer	Inorganic fertilizers
Pesticides	Pesticides and chemicals
Improved breeds	Improved livestock breeds
Agricultural productivity ( <i>Q</i> )	
Crop output	Value of total crop output per acre (thousands of 2000 UGX)
Livestock output	Value of total livestock output per tropical livestock unit (thousands of 2000 UGX)
Agricultural income ( <i>INC</i> )	
Agricultural revenue	Value of total agricultural output per adult equivalent (thousands of 2000 UGX) <sup>b</sup>
Market participation ( <i>MKT</i> )	
Marketed share_total	Percentage of total agricultural (crop, livestock, bird, aquaculture) output sold
Marketed share_crop	Percentage of total crop output sold
Marketed share_livestock	Percentage of total livestock output sold
Food and nutrition security ( <i>FNS</i> )	
Food security	
Improved	Situation has improved
No change	Situation has not changed
Worsened	Situation has worsened
Nutrition	
Improved	Situation has improved
No change	Situation has not changed
Worsened	Situation has worsened
Wealth	
Improved	Situation has improved
No change	Situation has not changed
Worsened	Situation has worsened
Explanatory variable	
Household level ( <i>H</i> )	
Gender of head	Whether female-headed household (1 if yes, 0 otherwise)
Age of head	Age of household head (years)
Education	Education of household head (cf. no formal education); proportion of members who
Primary	Attended or completed primary education
Postprimary	Attended or completed some postprimary education
Size	Number of adult equivalents in household
Income strategy	Primary source of income of household (cf. crops); proportion of members with
Livestock	Livestock as the primary source of income

(continued)

**Table 5.2—Continued**

Variable name <sup>a</sup>	Variable description
Other agriculture	Other agriculture as the primary source of income
Nonfarm activities	Nonfarm activities as the primary source of income
Farm level ( <i>F</i> )	
Land owned	Total farmland area owned (acres)
Crop area	Total farmland area under cultivation (acres)
Productive assets	Value of total agricultural productive assets—equipment and livestock (thousands of 2000 UGX)
Farmer group level ( <i>G</i> )	
Membership in other organization	Whether any household member belongs to any non-NAADS socioeconomic group (1 if yes, 0 otherwise)
Local government and community level ( <i>LC</i> )	
Average distance (km) to nearest	
Credit	Bank or credit association
All-weather road	All-weather road
Markets	Market and services (crop/livestock market, input supply, veterinary, and so on)

Source: NAADS-IFPRI 2004 and 2007 household panel surveys.

<sup>a</sup>Variables in parentheses represent factors presented in the conceptual framework.

<sup>b</sup>For adult equivalents, the household head, other adults (17 years and older), and children (16 years and younger) are weighted 1.000, 0.924, and 0.595, respectively (based on Appleton et al. 1999).

<sup>c</sup>Perception of change refers to change between 2000 and 2004 for the year 2004 and change between 2004 and 2007 for the year 2007.

and Western regions). To some extent, these regional dummies also control for some local government and community effects. The effect of national-level factors (*P*) is not explicitly controlled for because the measured values of the factors do not vary across the unit of observation, in this case households.

### Tests for Attrition and Sample Selection Bias

Before proceeding to the estimation and results of the treatment effects, we present the test results associated with attrition and potential sample selection bias. As explained in the Methodology section, we did two things. First, we applied the student *t*-test to the differences in the 2004 mean values of the explanatory variables between the 159 attritor households (mostly non-participants in the program) and the 719 households remaining in the panel sample, by the different groups. The distribution of attritors was 1, 4, 123, and 31 for  $NAADS_{DIR}$ ,  $NAADS_{NON-1}$ ,  $NAADS_{NON-2}$ , and  $NAADS_{NON-3}$ , respectively. Given the insignificant number of attritors in the first two groups, we carried out the test and present the results related to only  $NAADS_{NON-2}$  and  $NAADS_{NON-3}$ . The results in Table 5.3 show that for the  $NAADS_{NON-2}$  group, that is, those in

**Table 5.3—Test of attrition from the NAADS program and sample selection bias: Descriptive statistics**

Explanatory variable	NAADS <sub>NON-2</sub>			NAADS <sub>NON-3</sub>		
	Mean values		Student <i>t</i> -test of equality of means	Mean values		Student <i>t</i> -test of equality of means
	Nonattriters	Attriters	<i>F</i> -statistic	Nonattriters	Attriters	<i>F</i> -statistic
Gender of head	0.17	0.15	0.59	0.20	0.33	1.33
Age of head	43.66	41.33	1.75	42.14	40.99	0.09
Education (cf. none)						
Primary	0.70	0.50	7.67***	0.59	0.57	0.03
Postprimary	0.18	0.42	12.04***	0.24	0.35	0.81
Household size	5.00	4.44	6.13**	5.27	5.13	0.07
Income strategy (cf. crop)						
Livestock	0.05	0.05	0.02	0.04	0.05	0.19
Nonfarm activities	0.05	0.03	0.41	0.04	0.15	2.23
Other agriculture	0.16	0.16	0.00	0.19	0.18	0.01
Land owned	1.78	1.92	0.04	1.56	1.06	1.07
Productive assets	184.01	367.87	1.08	113.13	63.55	3.93**
Agricultural revenue	273.46	348.15	0.57	187.15	189.12	0.00
Membership in other organizations	0.47	0.54	0.77	0.43	0.22	3.50*
Distance to						
Credit	15.96	18.11	3.05*	26.86	32.50	0.79
All-weather road	2.48	2.24	0.69	2.52	3.61	4.72***
Markets	7.19	8.51	5.83***	8.54	9.37	0.39
Number of observations	284.00	123.00		113.00	31.00	

Source: NAADS-IFPRI 2004 and 2007 household surveys.

Notes: See Table 5.2 for a detailed description of the variables. Means are based on 2004 values. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Elsewhere, blank cells mean not applicable.

the same area where the program was implemented but who did not claim any benefits or contact with NAADS, attrition was significantly associated with better-educated households, smaller households, and households farther from credit and markets. For the  $NAADS_{NON-3}$  group, that is, those in areas where the program was never implemented by the time of the surveys, attrition was significantly associated with households poorer in assets and probably more isolated socially (with less membership in other organizations and farther from all-weather roads). Differences among attritors and nonattritors for the other variables are not statistically significant.

Although these results are comforting because the attritors differ from the nonattritors in a couple of variables only, any potential bias resulting from attrition will also depend on the extent to which those variables affect the participation decision as well as the outcomes. For example, because we expect better-educated households to be more likely to participate in the program and also to be better able to adopt technologies and thus attain better outcomes (other factors remaining the same), having better-educated attritors may lead to overestimation of the treatment effects, because it is the potentially worse performers who remain to be compared with the NAADS participants. We examine this issue further next.

Here we apply the BGLW test (Beckett et al. 1988) by regressing the initial value of agricultural income on the explanatory variables ( $x$ ), an attrition dummy (*attritor*), and interaction terms between the attrition dummy and  $x$  (Table 5.4 presents details of the regression estimates). The results of the joint  $F$ -test of the coefficients on the attrition dummy and the interaction variables suggest that attrition is likely to lead to biased estimates of the treatment effects. Still we do not know the scale and direction of the bias, which relates to the net effect of the coefficients on the attrition dummy and the interaction variables on agricultural income. Furthermore, because the estimation of the treatment effect of the NAADS program is to be based on a subsample of nonparticipants matched with participants, the test results (currently based on all attritors) are relevant to the extent to which attritors would have been selected or matched with the treatment observations.

We analyze these issues further by performing the two-stage estimation of agricultural revenue using the 2004 data, without and with the attritors. We present only the second-stage results, which show the percentage difference in agricultural revenue per capita between participants and nonparticipants of the program. The analysis, which is explained in more detail later, is carried out for different specifications of the probit selection equation and numbers of nearest-neighbor matches. First we look at the potential of attritors to be in the matched subsamples. As Table 5.5 shows, for the  $NAADS_{NON-2}$  group, the number of attritors included in the matched subsample

**Table 5.4—Test of attrition from the NAADS program and sample selection bias: BGLW test**

Explanatory variable	Subsample of $NAADS_{DIR}$ and $NAADS_{NON-2}$		Subsample of $NAADS_{DIR}$ and $NAADS_{NON-3}$
	I	II	
Gender of head	-0.392*	-0.417*	-0.372
In age of head	0.207	0.203	0.666
Education (cf. none)			
Primary	0.454*	0.499*	0.263
Postprimary	0.507	0.542	0.484
In household size	-0.132	-0.127	-0.147
Income strategy (cf. crop)			
Livestock	-0.089	0.004	-0.646
Nonfarm activities	0.276	0.337	-0.969**
Other agriculture	-0.254	-0.209	-0.873**
In land owned	0.232	0.145	0.143
In productive assets	0.238***	0.244***	0.212*
Membership in other organizations	0.072	0.066	-0.287
In distance to			
Credit	0.168	0.101	-0.992***
All-weather road	-0.118	-0.109	-0.122
Markets	-0.445**	-0.407**	0.256
Region (cf. Central)			
Eastern	-0.865**	-0.626**	-0.841**
Northern	-2.117***	-1.935***	n.e.**
Western	-0.105	-0.029	-1.584**
$NAADS\_years$ (cf. never)			
$NAADS\_year02-03$	-0.276		
$NAADS\_year01-02$	0.116		
Attritor	0.171	-0.290	0.869
Attritor × gender of head	-0.339	-0.221	-0.226
Attritor × In age of head	0.400	0.525	-0.316
Attritor × primary education	-0.650	-0.894	-0.406
Attritor × postprimary education	-0.597	-0.807	0.811
Attritor × In household size	-1.133*	-1.137*	0.687
Attritor × livestock	-0.030	0.043	0.575
Attritor × nonfarm activities	-0.679	-0.708	3.063**
Attritor × other agriculture	-0.398	-0.369	0.510
Attritor × In land owned	-0.206	-0.206	-1.082**
Attritor × In productive assets	-0.049	-0.052	-0.624**
Attritor × membership in other organizations	0.794**	0.744**	0.656*
Attritor × credit	0.037	0.095	0.409
Attritor × all-weather road	0.082	0.218	0.181
Attritor × markets	0.870	0.487	-0.211
Attritor × Eastern	-0.114	-0.206	0.966
Attritor × Northern	1.651**	1.674***	n.e.
Attritor × Western	-0.893	-0.784	0.175
Attritor × $NAADS\_year02-03$	-0.662	n.e.	n.e.

(continued)

Table 5.4—Continued

Explanatory variable	Subsample of $NAADS_{DIR}$ and $NAADS_{NON-2}$		Subsample of $NAADS_{DIR}$ and $NAADS_{NON-3}$
	I	II	
Attritor $\times$ NAADS_year01-02	-0.784	n.e.	n.e.
Intercept	3.930***	3.886***	5.077**
F-statistic	6.460***	6.790***	n.e.
R-squared	0.374***	0.364***	0.507***
Joint F-test (coefficients on attritor and interaction variables are jointly zero)	1.640**	1.720**	5.410***

Source: NAADS-IFPRI 2004 household survey.

Notes: The BGLW test is named for Beckett, Gould, Lillard, and Welch (1988), who proposed it. See Table 5.2 for a detailed description of the variables. The dependent variable (ln agricultural income per adult equivalent) and explanatory variables are based on 2004 values. ln: transformation by natural logarithm. n.e.: not estimated. I and II refer to models estimated with and without *NAADS\_years*, respectively. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Elsewhere, blank cells mean not applicable.

constitutes 13–28 percent of those included in the estimation or 7–50 percent of the total number of attritors within the group. For the  $NAADS_{NON-3}$  group, the equivalent percentages are 7–13 and 3–26, respectively. Now, looking at the results associated with the percentage difference in agricultural revenue per capita between participants and nonparticipants, we see that, in general, including attritors in the estimation leads to a more positive or less negative percentage difference, whereas excluding them leads to a less positive or more negative effect.<sup>1</sup> This is particularly the case for the probit model specification, including squared and interaction terms of the explanatory variables and estimation of the percentage difference based on matching with three neighbors, our preferred specification (about which more details will be given later). This means that attrition raises the initial bar against which participants in the program have to be compared. In other words, assuming that participation confers benefits leading to higher agricultural revenues and other things remain unchanged, a greater positive impact of the program will

<sup>1</sup> Note that only one of the estimated percentages of difference is statistically significant. This is not surprising because they are associated with the initial values for the analysis, which we expect to have been similar across participants and nonparticipants. This also lends credence to any significant effect found over time. The only significant effect that was found is not associated with our preferred model specification and estimation.

**Table 5.5—Test of attrition from the NAADS program and sample selection bias: Second-stage results of the percentage difference in agricultural revenue between matched participants and nonparticipants**

Model specification	Matched sample with attritors					
	Percentage difference	Number of non-NAADS participants	Attritors in matched subsample of nonparticipants		Matched sample without attritors	
			Percentage of non-NAADS participants	Percentage of total attritors <sup>a</sup>	Percentage difference	Number of non-NAADS participants
Level						
1 nearest neighbor						
NAADS <sub>NON-2</sub> I	16.37	60	13	7	-43.62	59
NAADS <sub>NON-2</sub> II	-3.20	60	28	14	-17.93	55
NAADS <sub>NON-3</sub>	41.06	29	7	6	-14.91	29
3 nearest neighbor						
NAADS <sub>NON-2</sub> I	-7.22	148	21	25	-0.41	141
NAADS <sub>NON-2</sub> II	-13.03	147	25	30	-12.60	131
NAADS <sub>NON-3</sub>	-7.20	61	10	19	7.08	54
5 nearest neighbor						
NAADS <sub>NON-2</sub> I	-1.66	202	23	38	4.10	193
NAADS <sub>NON-2</sub> II	-10.33	204	25	41	-9.74	181
NAADS <sub>NON-3</sub>	-15.88	77	10	26	-13.03	67
Levels + squareds						
1 nearest neighbor						
NAADS <sub>NON-2</sub> I	56.33	59	20	10	9.76	55
NAADS <sub>NON-2</sub> II	84.81*	57	25	11	-21.28	59
NAADS <sub>NON-3</sub>	25.99	31	13	3	13.40	28

3 nearest neighbor							
<i>NAADS</i> <sub>NON-2</sub> I	14.18	142	26	30	13.11	131	
<i>NAADS</i> <sub>NON-2</sub> II	28.31	137	22	24	-20.21	130	
<i>NAADS</i> <sub>NON-3</sub>	-12.39	52	13	23	-17.18	51	
5 nearest neighbor							
<i>NAADS</i> <sub>NON-2</sub> I	11.20	198	22	35	5.72	187	
<i>NAADS</i> <sub>NON-2</sub> II	19.47	185	22	33	-11.21	180	
<i>NAADS</i> <sub>NON-3</sub>	-7.85	65	12	26	-9.46	64	
Levels + squareds + interactions							
1 nearest neighbor							
<i>NAADS</i> <sub>NON-2</sub> I	13.22	61	18	50	-15.93	56	
<i>NAADS</i> <sub>NON-2</sub> II	-1.09	56	13	6	62.28	57	
<i>NAADS</i> <sub>NON-3</sub>	26.50	32	13	13	18.98	28	
3 nearest neighbor							
<i>NAADS</i> <sub>NON-2</sub> I	-10.05	152	25	31	-15.31	138	
<i>NAADS</i> <sub>NON-2</sub> II	1.38	152	14	18	-17.32	127	
<i>NAADS</i> <sub>NON-3</sub>	-5.84	53	11	19	-13.99	52	
5 nearest neighbor							
<i>NAADS</i> <sub>NON-2</sub> I	2.33	204	24	40	-4.90	179	
<i>NAADS</i> <sub>NON-2</sub> II	1.17	204	16	27	-13.42	174	
<i>NAADS</i> <sub>NON-3</sub>	-5.29	66	12	26	-9.46	64	

Source: NAADS-IFPRI 2004 household survey.

Notes: I and II indicate estimated with and without years of program length, respectively (see Table 5.4). Level refers to a first-stage selection probit estimated with natural logarithmic transformation of the continuous explanatory variables only; levels + squareds includes squared terms of the continuous variables; levels + squareds + interactions includes interaction terms (see Table 5.6 for details). \* indicates statistical significance at the 10 percent level.

<sup>a</sup>The total numbers of attriters were 123 and 31 for *NAADS*<sub>NON-2</sub> and *NAADS*<sub>NON-3</sub>, respectively.

be needed to show a significant positive effect when there is attrition (as will be estimated later) compared to when there is no attrition. Therefore, the estimated treatment effects of the program using the data at hand are likely to be underestimated, to the extent that the models are specified and estimated correctly.

### **Determinants of Participation in the NAADS Program: Overlap in Covariate Distributions**

As discussed earlier, to improve overlap in the covariate distributions, or common support, we tried different combinations and transformations of the explanatory variables ( $x$ ) in estimating the probit participation equation. Details are presented in Table 5.6. First we measured participation using the status observed in 2007, which is essentially measuring participation at any point in time because there were no dropouts. This is also important for the matching to ensure that participants are matched with nonparticipants in all years to avoid duplication or crossover. This way, a treatment household is always a treatment household and cannot switch status, and the same is true for a control household. Based on the different definitions of treatment (i.e., direct participants only, indirect participants only, or both) and controls (i.e., those with no exposure to the program), we estimated Equation 3.3 using the 2004 values of the explanatory variables and specifications shown in Table 5.6.

**Table 5.6—Description of NAADS participation models estimated**

<b>Feature</b>	<b>Description</b>
Variable	
Household	Inclusion of the variables measuring the household characteristics: gender, age, education, size, income strategy, and membership in other organizations
Outcomes	Initial value of outcome indicator (i.e., of the dependent variable to be estimated in the second-stage regression) plus inclusion versus exclusion of the variables measuring the 2004 values of potential explanatory endogenous variables (i.e., land owned and productive assets)
Higher level	Inclusion versus exclusion of the variables measuring the higher-level effects: access to services and regional location
NAADS program	Inclusion versus exclusion of the variable on the length of time the NAADS program has been in the subcounty ( <i>NAADS_years</i> )
Transformation	
Squared	Inclusion versus exclusion of squared values of the continuous variables
Logs	Inclusion versus exclusion of logarithmic values of the continuous variables
Interaction	Inclusion versus exclusion of interaction terms among different variables: gender $\times$ education and gender $\times$ land owned

Source: Authors' specification of the models to be estimated.

We tried several specifications to see which ones offer the best common support. However, we present only the results (probits, histograms, and balancing tests) associated with six different specifications to show how different covariates and transformations yield different outcomes of overlap or common support. The six specifications are shown in Table 5.7, starting with a base model that includes natural logarithmic transformation of the continuous explanatory variables only and then adding squared values and interaction terms sequentially. The corresponding probit results are shown in Tables 5.8–5.10, the histograms of the estimated propensity scores in Figures 5.1–5.3, and the balancing tests in Tables 5.11–5.13.

The probit results (see Tables 5.8–5.10) show that different covariates have different types of influence (sign, magnitude, and statistical significance) on the decision to participate or not to participate in the NAADS program across different groups of households by location relative to where the program is implemented.<sup>2</sup> This is not surprising. It reflects different behavior of households based on their different endowments and resources to take advantage of the NAADS programs vis-à-vis different levels of exposure or nonexposure to the program. Regardless of the specification and the control group used in the analysis, however, we find that household size has a statistically significant negative association with participation, suggesting that the NAADS program may be seen to offer immediate labor-saving technologies, such as pesticides, which reduce the labor needed for weeding, for example. Other factors with consistent sign across different specifications and control groups include sources of income (positive for livestock and nonfarm activities and negative for other agriculture) and amount of land owned (negative). The effects of livestock and other agricultural income sources were not statistically significant, whereas the effect of land ownership was statistically significant in the comparison with  $NAADS_{NON-1}$  households only. Membership in other organizations has an opposing effect, negative and positive with respect to the estimation involving  $NAADS_{NON-1}$  and  $NAADS_{NON-3}$  households, respectively. Being closer to infrastructure and services was associated with greater likelihood of participation, particularly for access to credit among households in comparison with  $NAADS_{NON-3}$  households. Location by region was also important for participation, particularly location in the Eastern Region for households in comparison with  $NAADS_{NON-1}$  households and location in the Eastern and Western regions for households in comparison with  $NAADS_{NON-3}$  households.

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<sup>2</sup> The goodness of fit of the overall model, that is, the chi-squared statistic, with respect to  $NAADS_{NON-2}$  (see Table 5.9) is not statistically significant, so we focus the discussion on the other two.

**Table 5.7—Description of NAADS participation models estimated and presented**

Model	Variable				Transformation			Remarks or sensitivity to base model
	Household	Outcomes	Higher level	NAADS program	Squared	Logs	Interaction	
I	Included	Included	Included	Excluded	Excluded	Included	Excluded	Base model
II	Included	Included	Included	Excluded	Included	Included	Excluded	I plus inclusion of squared terms
III	Included	Included	Included	Excluded	Included	Included	Included	II plus inclusion of interaction terms
IV	Included	Included	Included	Included	Excluded	Included	Excluded	I plus inclusion of program length
V	Included	Included	Included	Included	Included	Included	Excluded	II plus inclusion of program length
VI	Included	Included	Included	Included	Included	Included	Included	III plus inclusion of program length

Source: Authors' specification of the models to be estimated.

**Table 5.8—First-stage probit selection equation results,  $NAADS_{DIR}$  and  $NAADS_{NON-1}$** 

Explanatory variable	Model					
	I	II	III	IV	V	VI
Gender of head	0.091	0.022	0.044	-0.002	-0.070	-0.013
In age of head	-0.249	7.652	7.734	-0.057	6.599	7.361
Education (cf. none)						
Primary	-0.069	-0.171	-0.216	-0.080	-0.172	-0.257
Postprimary	-0.209	-0.300	-0.082	-0.200	-0.278	-0.006
In household size	-0.376	-0.407 *	-0.406 *	-0.502 **	-0.523 **	-0.520 **
Income strategy (cf. crop)						
Livestock	0.619	0.587	0.588	0.691	0.669	0.711
Nonfarm activities	0.712	0.692	0.717	0.933 *	0.908 *	0.966 *
Other agriculture	-0.250	-0.300	-0.314	-0.293	-0.350	-0.419
In land owned	-0.199 *	-0.200 *	-0.245 *	-0.297 **	-0.296 **	-0.406 ***
In productive assets	0.008	0.152	0.162	-0.023	0.264	0.282
Membership in other organizations	-1.002 ***	-1.067 ***	-1.075 ***	-1.064 ***	-1.135 ***	-1.171 ***
In agricultural revenue	-0.100	-0.097	-0.098	-0.060	-0.056	-0.058
In distance to						
Credit	-0.042	-0.050	-0.047	-0.075	-0.079	-0.080
All-weather road	0.090	0.088	0.087	0.031	0.033	0.020
Markets	-0.124	-0.109	-0.103	-0.046	-0.032	-0.006
Region (cf. Central)						
Eastern	0.471	0.455	0.480	0.580 *	0.561	0.608 *
Northern	-0.171	-0.210	-0.184	-0.160	-0.213	-0.172
Western	0.143	0.097	0.114	-0.130	-0.191	-0.181
$NAADS_{years}$ (cf. never)						
$NAADS_{year02-03}$				-7.915 ***	-7.935	-8.119 ***
$NAADS_{year01-02}$				-8.209 ***	-8.248	-8.416 ***
Squared terms						
In age of head		-1.060	-1.070		-0.893	-0.990
In land owned		0.002	0.016		0.005	0.036
In productive assets		-0.007	-0.008		-0.014	-0.015
Interaction terms						
Gender of head × postprimary education			-0.291			-0.398
Gender of head × In land owned			0.240			0.559 *
Intercept	2.774	-12.348	-12.527	10.123 ***	-3.379 ***	-4.735
Wald chi-squared	70.730 ***	72.130 ***	73.080 ***	106.180 ***	107.240 ***	110.930 ***
Pseudo $R$ -squared	0.227	0.231	0.234	0.340	0.344	0.355

Source: NAADS-IFPRI 2004 and 2007 household surveys.

Notes: See Tables 5.1 and 5.2 for a detailed description of the variables. The dependent variable is equal to one for participants ( $NAADS_{DIR}$ ) and zero for the respective nonparticipants. The explanatory variables are 2004 values. In: transformation by natural logarithm. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Elsewhere, blank cells mean not applicable.

**Table 5.9—First-stage probit selection equation results,  $NAADS_{DIR}$  and  $NAADS_{NON-2}$** 

Explanatory variable	Model					
	I	II	III	IV	V	VI
Gender of head	0.348	0.321	0.251	0.337	0.312	0.248
ln age of head	0.119	4.048	3.992	0.132	3.822	3.720
Education (cf. none)						
Primary	0.192	0.080	0.067	0.117	0.032	0.011
Postprimary	0.351	0.213	0.526	0.274	0.164	0.536
ln household size	-0.225	-0.192	-0.182	-0.227	-0.204	-0.195
Income strategy (cf. crop)						
Livestock	0.282	0.316	0.329	0.221	0.265	0.284
Nonfarm	0.492	0.479	0.496	0.505	0.498	0.520
Other agriculture	-0.240	-0.238	-0.217	-0.256	-0.252	-0.233
ln land owned	-0.156 *	-0.122	-0.096	-0.153 *	-0.131	-0.113
ln productive assets	0.047	0.210	0.227	0.047	0.222	0.243
Membership in other organizations	0.000	-0.028	-0.022	0.000	-0.024	-0.014
ln agricultural revenue	0.087	0.084	0.084	0.093	0.088	0.089
ln distance to						
Credit	-0.124	-0.129	-0.121	-0.168	-0.172	-0.162
All-weather road	-0.002	0.011	0.012	-0.003	0.009	0.010
Markets	-0.016	0.019	0.022	0.019	0.047	0.051
Region (cf. Central)						
Eastern	0.310	0.325	0.338	0.189	0.250	0.254
Northern	0.412	0.387	0.402	0.395	0.392	0.407
Western	0.308	0.305	0.312	0.143	0.159	0.164
NAADS_years (cf. never)						
NAADS_year02-03				-0.655 **	-0.573 *	-0.582 *
NAADS_year01-02				-0.551 **	-0.540 *	-0.533 *
Squared terms						
ln age of head		-0.531	-0.525		-0.499	-0.486
ln land owned		-0.087	-0.090		-0.079	-0.078
ln productive assets						
Interaction terms		-0.008	-0.009		-0.009	-0.010
Gender of head × postprimary education			-0.365			-0.439
Gender of head × ln land owned			-0.107			-0.061
Intercept	-2.665 *	-10.476	-10.438	-2.047	-9.527	-9.446
Wald chi-squared	15.620	19.910	20.350	20.820	24.210	24.610
Pseudo R-squared	0.048	0.062	0.063	0.065	0.075	0.076

Source: NAADS-IFPRI 2004 and 2007 household surveys.

Notes: See Tables 5.1 and 5.2 for a detailed description of the variables. The dependent variable is equal to one for participants ( $NAADS_{DIR}$ ) and zero for the respective nonparticipants. The explanatory variables are 2004 values. ln: transformation by natural logarithm. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Elsewhere blank cells mean not applicable.

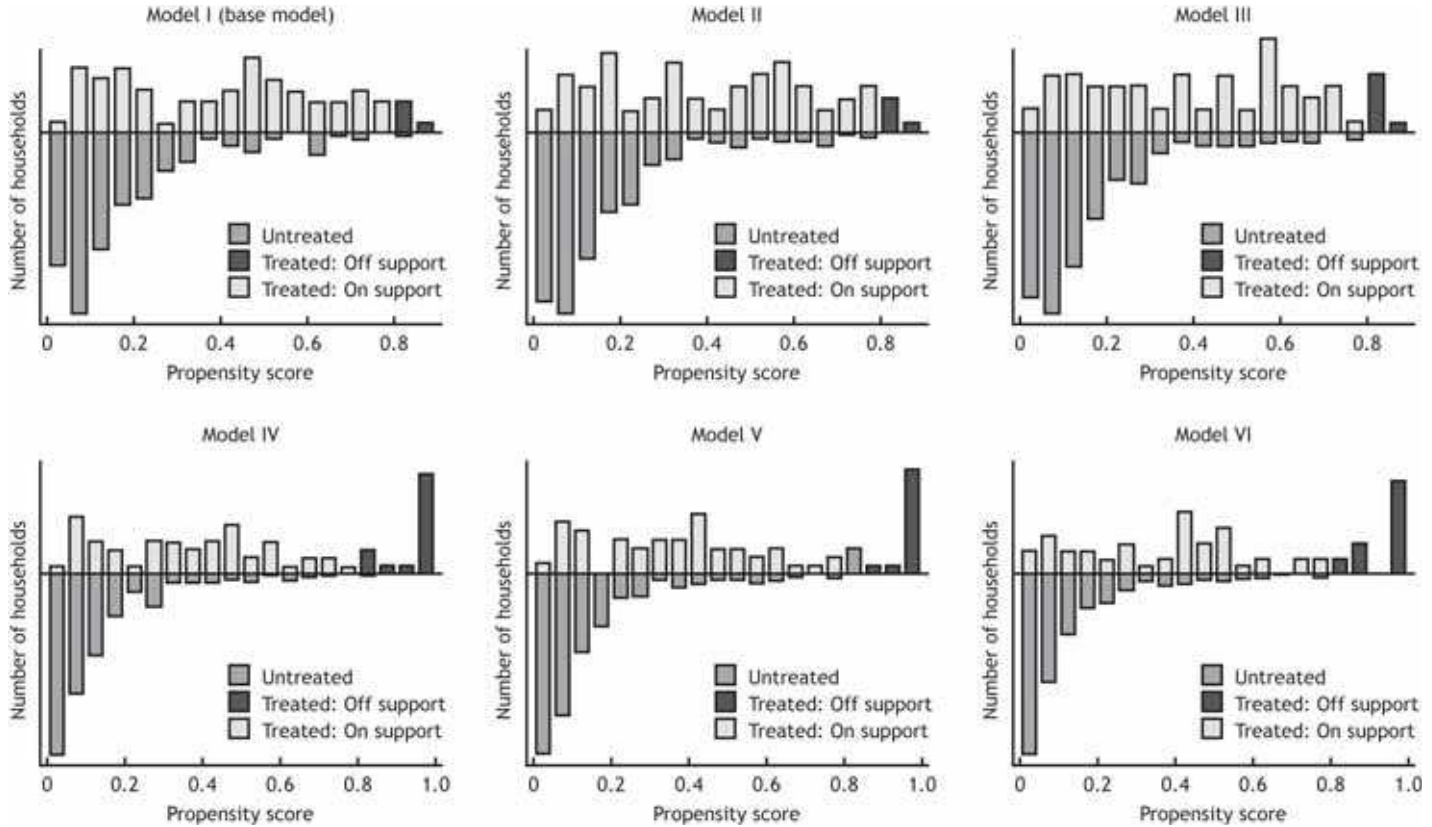
**Table 5.10—First-stage probit selection equation results,  $NAADS_{DIR}$  and  $NAADS_{NON-3}$** 

Explanatory variable	Model		
	I	II	III
Gender of head	0.072	0.157	0.149
In age of head	0.255	5.786	5.787
Education (cf. none)			
Primary	0.238	0.285	0.286
Postprimary	0.306	0.321	0.287
In household size	-0.438 *	-0.497 *	-0.502 *
Income strategy (cf. crop)			
Livestock	0.310	0.264	0.265
Nonfarm activities	0.892 *	1.126 *	1.109 *
Other agriculture	-0.241	-0.238	-0.236
In land owned	-0.057	-0.149	-0.129
In productive assets	-0.077	-1.222	-1.206
Membership in other organizations	0.361	0.448 *	0.446 *
In agricultural revenue	-0.015	0.021	0.019
In distance to			
Credit	-0.214	-0.218 *	-0.218 *
All-weather road	-0.141	-0.156	-0.156
Markets	-0.035	-0.010	-0.010
Region (cf. Central)			
Eastern	0.493	0.683 *	0.673 *
Northern	n.e.	n.e.	n.e.
Western	1.528 ***	1.620 ***	1.611 ***
Squared terms			
In age of head		-0.757	-0.758
In land owned		-0.061	-0.061
In productive assets		0.057	0.057
Interaction terms			
Gender of head × postprimary education			0.046
Gender of head × In land owned			-0.060
Intercept	-0.015	-5.087	-5.117
Wald chi-squared	43.970 ***	46.680 ***	46.740 ***
Pseudo R-squared	0.196	0.208	0.209

Source: NAADS-IFPRI 2004 and 2007 household surveys.

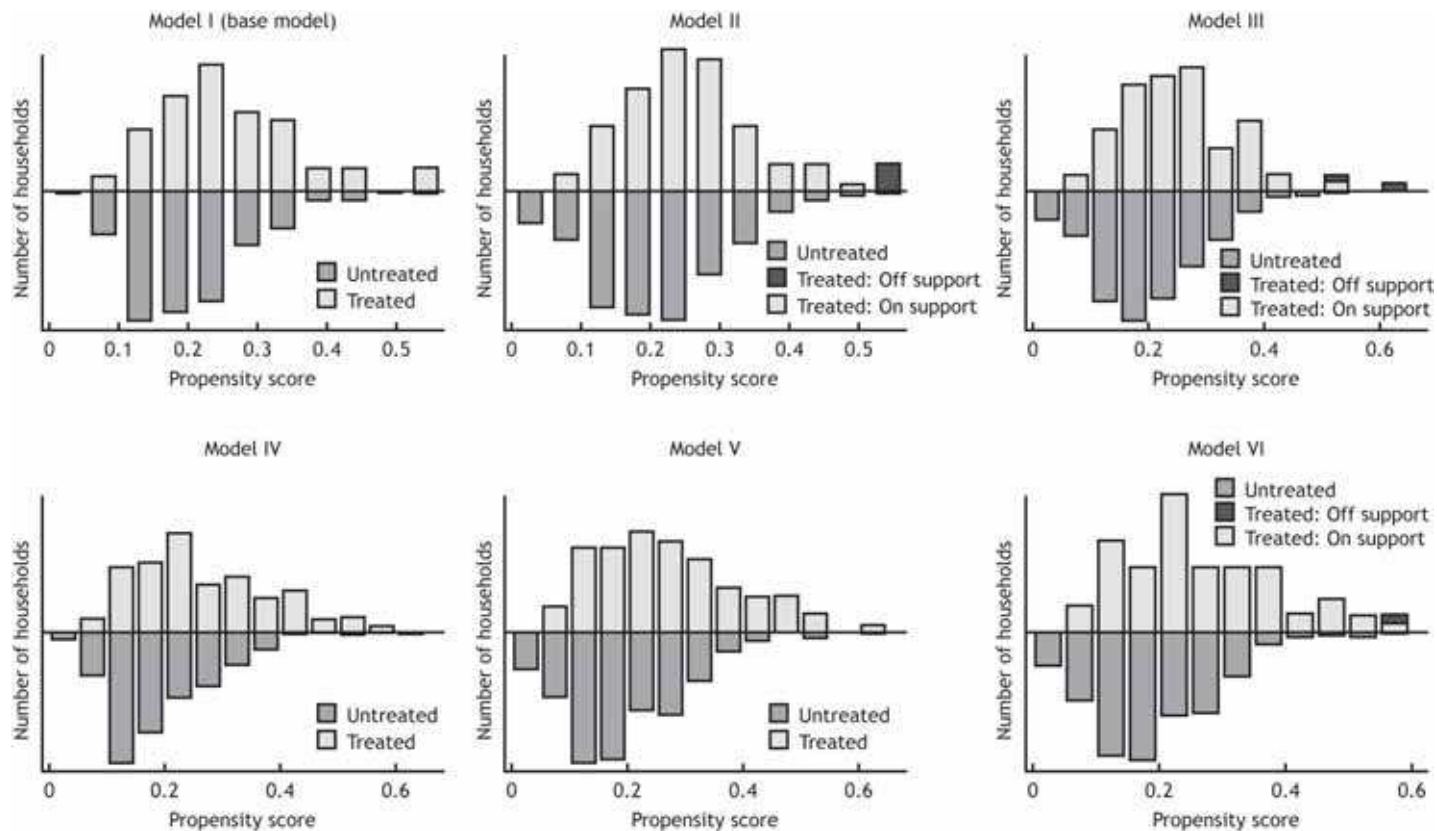
Notes: See Tables 5.1 and 5.2 for a detailed description of the variables. The dependent variable is equal to one for participants ( $NAADS_{DIR}$ ) and zero for the respective non-participants. The explanatory variables are 2004 values. In: transformation by natural logarithm; n.e.: not estimated. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Elsewhere, blank cells mean not applicable. The coefficients associated with the variable program length ( $NAADS_{years}$ ) and models IV, V, and VI are not estimated because  $NAADS_{years}$  is not defined for  $NAADS_{NON-3}$ .

Figure 5.1—Histogram of estimated propensity scores,  $NAADS_{DIR}$  (top bars) and  $NAADS_{NON-1}$  (bottom bars)



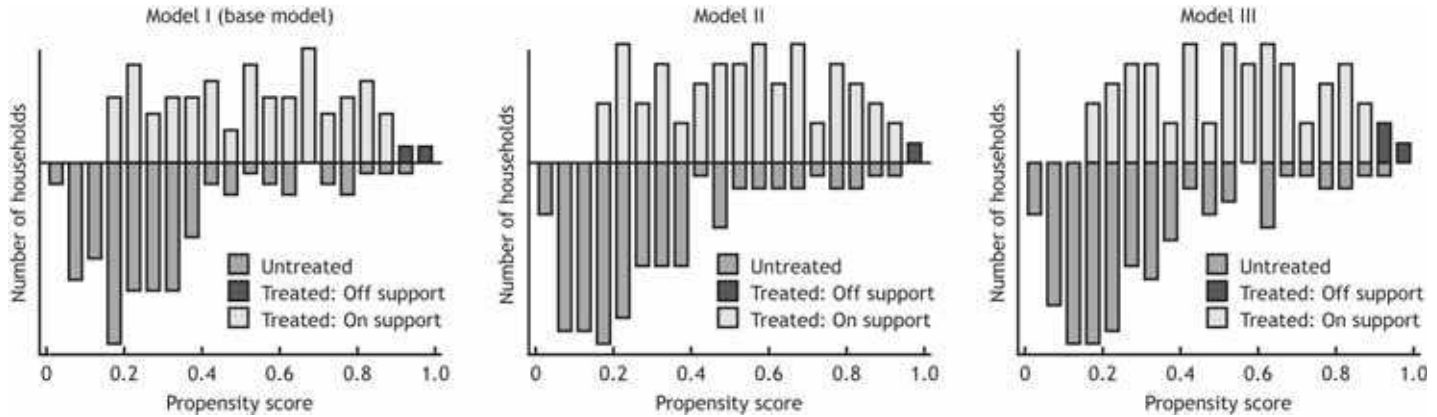
Source: First-stage probit selection equation estimation results.

Figure 5.2—Histogram of estimated propensity scores,  $NAADS_{DIR}$  (top bars) and  $NAADS_{NON-2}$  (bottom bars)



Source: First-stage probit selection equation estimation results.

Figure 5.3—Histogram of estimated propensity score,  $NAADS_{DIR}$  (top bars) and  $NAADS_{NON-3}$  (bottom bars)



Source: First-stage probit selection equation estimation results.

Note: Models IV, V, and VI are not estimated because the variable program length ( $NAADS\_years$ ) is not defined for  $NAADS_{NON-3}$ .

**Table 5.11—Balancing test on initial values (2004) of observed characteristics, NAADS<sub>DIR</sub>, and NAADS<sub>NON-1</sub>**

Explanatory variable	Unmatched sample			Matched sample / model					
	Mean value			I	II	III	IV	V	VI
	Treated	Control	Percent bias	Percent bias	Percent bias	Percent bias	Percent bias	Percent bias	Percent bias
Gender of head	0.205	0.131	19.9**	7.2	4.6	-3.0	-10.5	1.8	0.0
Age of head	42.833	45.357	-18.4**	-0.1	9.2	2.3	23.0	12.3	-3.6
Education									
Primary	0.641	0.548	19.1**	-20.9	-2.3	-25.0	-25.4	-26.4	-15.6
Postprimary	0.205	0.349	-32.6***	8.5	13.0	21.3	16.2	18.4	23.5
Household size	4.571	5.415	-36.8***	16.3	11.3	0.7	6.7	19.7	10.1
Membership in other organizations	0.385	0.835	-103.9***	14.9	0.0	6.4	-1.5	-6.3	-1.6
Income strategy									
Livestock	0.064	0.032	15.2*	15.1	-10.8	5.2	0.0	0.0	9.8
Nonfarm activities	0.077	0.016	29.3***	18.0	11.0	10.6	12.5	13.0	-3.3
Other	0.103	0.167	-18.8*	-3.2	-15.2	-6.5	13.4	2.0	-4.1
Land owned	1.238	3.309	-16.9	-0.7	-1.8	-0.5	0.7	0.4	0.9
Productive assets	150.000	240.000	-13.5	2.3	3.5	4.0	-0.2	3.9	-2.4
Agricultural revenue	193.140	320.370	-30.9***	-0.5	6.4	11.5	7.5	11.8	5.6
Distance to									
Credit	18.726	19.882	-8.2	25.5	30.4	9.6	15.6	28.9	18.8
All-weather road	2.606	2.382	4.8	15.2	-7.6	17.3	-7.6	-9.2	-9.1
Markets	6.918	9.354	-37.9***	13.6	-1.8	-0.3	2.0	5.2	4.3
Region									
Eastern	0.244	0.125	30.7***	8.4	9.0	-8.7	1.7	8.9	0.0
Northern	0.205	0.278	-17.1*	-13.8	-2.7	-9.1	-4.6	1.6	-8.1
Western	0.423	0.420	0.7	5.4	-2.3	3.4	-4.0	-8.2	9.8
NAADS_years (cf. never)									
NAADS_year02-03	0.359	0.459	-20.4**				0.0	-16.7	-5.7
NAADS_year01-02	0.474	0.541	-13.4				0.0	16.3	5.6
Off-support treated observations				4.0	8.0	6.0	15.0	17.0	18.0

Source of data: NAADS-IFPRI 2004 household survey.

Notes: See Table 5.2 for a detailed description of the variables. Means are based on 2004 values. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Elsewhere, blank cells mean not applicable.

Table 5.12—Balancing test on initial values (2004) of observed characteristics,  $NAADS_{DIR}$  and  $NAADS_{NON-2}$ 

Explanatory variable	Unmatched sample			Matched sample / model					
	Mean value		Percent bias	I	II	III	IV	V	VI
	Treated	Control		Percent bias	Percent bias	Percent bias	Percent bias	Percent bias	Percent bias
Gender of head	0.205	0.161	11.3	2.6	-6.8	2.7	-3.9	5.2	4.0
Age of head	42.833	43.225	-2.8	-4.4	3.4	4.9	14.8	12.3	4.5
Education									
Primary	0.641	0.663	-4.6	-1.1	10.0	4.4	-5.3	7.4	-2.1
Postprimary	0.205	0.175	7.6	2.6	-16.2	-10.6	3.9	-5.1	-3.9
Household size	4.571	4.924	-15.1*	-1.4	-11.7	-0.3	5.8	4.2	2.7
Membership in other organizations	0.385	0.440	-11.3	13.3	-4.3	3.2	1.0	2.1	-4.2
Income strategy									
Livestock	0.064	0.056	3.3	2.1	-4.4	-4.4	-12.7	-6.4	8.6
Nonfarm activities	0.077	0.049	11.4	0.0	6.5	-6.4	8.3	4.2	-12.7
Other	0.103	0.140	-11.6	-3.1	-6.5	-3.2	6.2	4.6	-3.1
Land owned	1.238	2.614	-21.7*	0.0	-1.1	-1.5	-14.7	-2.0	-2.0
Productive assets	150.000	290.000	-16.6	2.7	2.4	2.3	-8.5	1.5	4.2
Agricultural revenue	193.140	222.860	-7.3	6.0	-2.0	-0.6	-7.3	-4.3	2.6
Distance to									
Credit	18.726	16.784	14.6	26.8	21.2	27.9	13.5	18.2	20.1
All-weather road	2.606	2.552	1.2	19.0	15.5	9.3	5.7	9.8	18.8
Markets	6.918	7.667	-15.8	-3.0	-12.8	-3.4	-4.0	-14.9	5.9
Region									
Eastern	0.244	0.283	-9.0	-19.5	19.2	-5.9	-2.3	-1.1	-8.1
Northern	0.205	0.130	20.3**	1.4	-5.7	7.0	-4.1	2.7	-4.1
Western	0.423	0.399	4.8	13.3	-10.7	4.2	3.1	-2.0	18.7
NAADS_years (cf. never)									
NAADS_year02-03	0.359	0.365	-1.3				0.0	-2.1	-2.1
NAADS_year01-02	0.474	0.549	-15.0*				1.0	1.0	0.0
Off-support treated observations				0.0	3.0	2.0	0.0	0.0	1.0

Source: NAADS-IFPRI 2004 household survey.

Notes: See Table 5.2 for a detailed description of the variables. Means are based on 2004 values. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Elsewhere, blank cells mean not applicable.

**Table 5.13—Balancing test on initial values (2004) of observed characteristics, *NAADS<sub>DIR</sub>*, and *NAADS<sub>NON-3</sub>***

Explanatory variable	Unmatched sample			Matched sample / model		
	Mean value		Percent bias	I	II	III
	Treated	Control		Percent bias	Percent bias	Percent bias
Gender of head	0.205	0.241	-8.6	12.5	8.6	2.5
Age of head	42.833	42.795	0.3	-11.7	-19.9	-22.8
Education						
Primary	0.641	0.607	7.0	-7.5	-2.1	5.5
Postprimary	0.205	0.223	-4.4	12.7	6.2	6.4
Household size	4.571	5.205	-24.7**	10.7	3.2	5.5
Membership in other organizations	0.385	0.444	-12.1	14.8	0.0	6.4
Income strategy						
Livestock	0.064	0.045	8.6	11.5	11.3	9.3
Nonfarm activities	0.077	0.036	17.9*	27.1*	17.8	18.4
Other	0.103	0.161	-17.2	4.6	7.6	4.7
Land owned	1.238	1.824	-13.0	-1.5	-2.4	-4.0
Productive assets	150.000	120.000	7.9	1.1	-2.5	-3.3
Agricultural revenue	193.140	203.380	-3.5	17.9	9.6	8.1
Distance to						
Credit	18.726	28.337	-45.2***	9.1	5.1	7.3
All-weather road	2.606	2.755	-3.5	23.8	27.0*	29.2*
Markets	6.918	9.238	-28.2**	9.8	10.2	7.8
Region						
Eastern	0.244	0.641	-87.1***	-43.4**	-50.6***	-46.4**
Northern	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
Western	0.423	0.094	80.9***	6.4	17.6	20.8
Off-support treated observations				1.0	1.0	3.0

Source: NAADS-IFPRI 2004 household survey.

Notes: See Table 5.2 for a detailed description of the variables. Means are based on 2004 values. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. The coefficients associated with the variable program length (*NAADS\_years*) and models IV, V, and VI are not estimated because *tNAADS\_years* is not defined for *NAADS<sub>NON-3</sub>*.

Gender, age, and education did not have a statistically significant effect on participation. Although they all had a positive effect among households in comparison with  $NAADS_{NON-3}$  households, they had a mixed effect (mostly positive in the case of age and negative in the case of education) for households in comparison with  $NAADS_{NON-1}$  households.

Although the higher-order (i.e., squared and interaction) terms generally had no statistically significant effect on the likelihood of participation by themselves, their inclusion in the estimation strengthened the effect (i.e., increased the magnitude) and statistical significance of the other factors included in the model.

Interestingly, the probit results show that the longer the NAADS program has been in the subcounty, the less likely farmers are to participate directly in the program, suggesting that farmers may be giving up direct participation with time. This is not surprising and is likely due to several factors. Generally, it reflects declining net gain from direct participation. It is possible that farmers may not have received grants they expected to receive or that the cost of participation, including membership fees, has exceeded the benefits from any grants and other benefits received. The findings from analysis of the farmer group surveys also reflect the possibility that farmers dropped out when their preferred enterprise(s) was not selected among the three promoted in the subcounty or when the focus of the program graduated from their preferred enterprise(s) to others. Indirect participation (associated with  $NAADS_{NON-1}$ ) or exposure to information (associated with  $NAADS_{NON-2}$ ) may meet their needs. These results are consistent with those of Benin et al. (2011), although it may not seem so at first glance, because those researchers found participation positively associated with the length of program implementation. However, Benin et al. (2011) define participation as including both direct and indirect participation (i.e.,  $NAADS_{DIR} + NAADS_{NON-1}$ ) and nonparticipation irrespective of exposure ( $NAADS_{NON-2} + NAADS_{NON-3}$ ). Therefore, some of the findings on the determinants of participation in the NAADS program in Benin et al. (2011) are also different. Because we have seen that different covariates have different types of influence (sign, magnitude, and statistical significance) on the decision to participate or not to participate in the NAADS program across different groups of households by location relative to where the program is implemented, our findings suggest that pooling observations for the different unique groups as was done in Benin et al. (2011) could lead to different policy implications and, as we shall see later, limit any potential gain from matching each direct participant with multiple non-participants that are similar in several attributes but different in many others.

At first glance, the histograms of the estimated propensity scores resulting from the probits and presented in Figures 5.1–5.3 do not seem very different, suggesting that different specifications of the probit model are not likely to yield different outcomes of common support. The general pattern of the histograms, however, is a skewness of the propensity scores toward one for the treated observations ( $NAADS_{DIR}$ ) and skewness toward zero for the comparison observations ( $NAADS_{NON-1}$ ,  $NAADS_{NON-2}$ , and  $NAADS_{NON-3}$ ), with the situation most perverse when the variable measuring the length of the program ( $NAADS\_years$ ) is included in the case with  $NAADS_{NON-1}$  (see Figure 5.1). The balancing test results presented in Tables 5.11–5.13 also show that including the length of the program (i.e., Models IV–VI) will likely undermine the results because several treated observations will have to be dropped to achieve adequate common support.

Combining the results just presented, that is, probits, histograms, and balancing tests, suggests that Model III (i.e., inclusion of squared and interaction terms and excluding the length of the program) is the preferred model because there is more common support, that is, more control observations in the upper bins of the propensity scores. Nevertheless, we still estimate the *ATTs* with the other model specifications, particularly Models I and II, to assess the sensitivity of the results.

### **Impact of NAADS: Second-Stage Model Specification, Estimation, and Results**

To assess the impact of the NAADS program on the different outcome variables presented earlier, we used different estimators in the second stage depending on how each outcome variable was measured. For dichotomous discrete variables such as adoption of technologies and practices, we used the random-effects probits estimator rather than the fixed-effects estimator because the conditional fixed-effects estimator is difficult to obtain, whereas the unconditional fixed-effects estimator is biased. For multiple-choice discrete variables such as perception of change in welfare (measured by increase, no change, or decrease in food and nutrition security and wealth), we used multinomial probit regression. For continuous-outcome variables, including number of extension visits received and agricultural (crop, livestock, and total) marketed output and revenue, we used weighted least squares. For the continuous-outcome variables, the impact of the program was also assessed using the PSM. We also considered different specifications of the second-stage estimator to assess the sensitivity of the results. For each of Models I, II, and III, described in Table 5.7, the different specifications comprised (1) estimation without and with the covariates,  $x_j$ ; (2) no correction versus correction for stratification, clustering, and weighting of sample;

and (3) inclusion and exclusion of potential endogenous variables such as change in adoption of technologies, assets, and agricultural revenue.<sup>3</sup> These are explained further in Table 5.14. In presenting the detailed results, however, we are selective, especially for results that do not have much variation across the different estimators and specifications.

Before moving on to the estimated impacts, Table 5.15 shows a distribution of the matched subsamples associated with the different matches used, that is, 1, 3, 5, and 10 nearest neighbors.

### **Access to Advisory Services**

Here we analyze change between 2004 and 2007 in the number of extension visits received by farmers. The descriptive statistics in Figure 5.4 shows that although the average number of extension visits received by direct participants in the program ( $NAADS_{DIR}$ ) increased by about 54 percent, from 2.5 to 3.8 in 2004 and 2007, respectively, the number received by indirect participants and nonparticipants in the program fell. The relative reduction was most severe for  $NAADS_{NON-2}$  and  $NAADS_{NON-3}$ . Indirect participants ( $NAADS_{NON-1}$ ) maintained the highest number of visits in both years, with 10 and 9 visits, respectively. Although extension is moving away from individual farm visits toward the farmer group approach, these dynamics reflect a shift in allocation of resources toward the NAADS program.

### **Impact of the NAADS Program on Change in Access to Advisory Services**

The second-stage results summarized in Table 5.16 show that farmers participating directly in the NAADS program ( $NAADS_{DIR}$ ) were associated with greater increase in access to advisory services when compared to their nonparticipating counterparts, based in either the same areas where the program was implemented ( $NAADS_{NON-2}$ ) or elsewhere ( $NAADS_{NON-3}$ ). When they are compared to indirect participants ( $NAADS_{NON-1}$ ), however, the opposite holds, because indirect participants ( $NAADS_{NON-1}$ ) received many more extension visits in 2004 and 2007, with only a slight drop (see Figure 5.4). The larger estimates associated with the model specification without the covariates suggest that changes in other factors have been important, including changes in access to road infrastructure (see Table A.1 for selected detailed regression results). In general, the estimates associated with the subsample based on matching with a single nearest neighbor are inconsistent when compared to those based on matching with 3 or 5 nearest neighbors. They are often very

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<sup>3</sup> The same approach is used in the estimation of marketed shares and agricultural income, to be discussed later.

**Table 5.14—Description of estimators and model specifications used in the second-stage estimation**

Estimator / model specification	Model abbreviation	Number of nearest neighbors	Correction for sampling frame?	Inclusion and exclusion of potential endogenous variables?
Propensity score matching (PSM)				
1 neighbor	PSM 1	1	No	n.a.
3 neighbors	PSM 2	3	No	n.a.
5 neighbors	PSM 3	5	No	n.a.
Two-stage weighted regression (2SWR) (without covariates)				
1 neighbor, no correction	2SWR 1, no	1	No	n.a.
1 neighbor, correction	2SWR 1, yes	1	Yes	n.a.
3 neighbors, no correction	2SWR 3, no	3	No	n.a.
3 neighbors, correction	2SWR 3, yes	3	Yes	n.a.
5 neighbors, no correction	2SWR 5, no	5	No	n.a.
5 neighbors, correction	2SWR 5, yes	5	Yes	n.a.
2SWR (with covariates)				
1 neighbor, no correction, include endogenous	2SWR 1, no, in	1	No	Include
1 neighbor, correction, include endogenous	2SWR 1, yes, in	1	Yes	Include
3 neighbors, no correction, include endogenous	2SWR 3, no, in	3	No	Include
3 neighbors, correction, include endogenous	2SWR 3, yes, in	3	Yes	Include
5 neighbors, no correction, include endogenous	2SWR 5, no, in	5	No	Include
5 neighbors, correction, include endogenous	2SWR 5, yes, in	5	Yes	Include
1 neighbor, no correction, exclude endogenous	2SWR 1, no, ex	1	No	Exclude
1 neighbor, correction, exclude endogenous	2SWR 1, yes, ex	1	Yes	Exclude
3 neighbors, no correction, exclude endogenous	2SWR 3, no, ex	3	No	Exclude
3 neighbors, correction, exclude endogenous	2SWR 3, yes, ex	3	Yes	Exclude
5 neighbors, no correction, exclude endogenous	2SWR 5, no, ex	5	No	Exclude
5 neighbors, correction, exclude endogenous	2SWR 5, yes, ex	5	Yes	Exclude

Source: Authors' definitions and assumptions.

Note: n.a.: not applicable.

**Table 5.15—Number of observations associated with the matched and unmatched subsamples used in the estimation of the average treatment effects on the treated (ATTs)**

Matching option	NAADS <sub>NON-1</sub>	NAADS <sub>NON-2</sub>	NAADS <sub>NON-3</sub>
Matched			
1 neighbor	40	53	32
3 neighbors	93	125	55
5 neighbors	119	164	69
Unmatched	256	284	113

Source: NAADS-IFPRI 2004 and 2007 household surveys (panel data).

Note: The treatment group is NAADS<sub>DIR</sub>, with 65 and 66 matched and unmatched observations, respectively.

**Table 5.16—Impact of the NAADS program on change in the number of extension visits received between 2004 and 2007 (percentage difference between treatment [NAADS<sub>DIR</sub>] and different control groups)**

Estimator/model	ATT <sub>NON-1</sub>	ATT <sub>NON-2</sub>	ATT <sub>NON-3</sub>
Propensity score matching (PSM)			
Model I			
1 neighbor	-35.18	123.17 **	123.89
3 neighbors	-10.38	126.61 ***	103.62 *
5 neighbors	-9.83	133.78 ***	136.66 **
Model II			
1 neighbor	28.33	114.61 **	85.93
3 neighbors	-3.61	133.58 ***	93.53
5 neighbors	-14.72	127.71 ***	103.78 **
Model III			
1 neighbor	-57.43	73.25	93.49 *
3 neighbors	-36.00	104.98 **	91.35 *
5 neighbors	-18.85	112.04 ***	104.39 *
Two-stage weighted regression (2SWR) (without covariates)			
Model I			
1 neighbor, no correction	19.30 ***	89.12 ***	116.91 ***
1 neighbor, correction	17.49 ***	82.47 ***	119.65 ***
3 neighbors, no correction	-88.17 *	87.13 ***	82.79 ***
3 neighbors, correction	-146.60 **	85.26 ***	90.11 ***
5 neighbors, no correction	-78.95 **	91.71 ***	90.15 ***
5 neighbors, correction	-127.94 **	87.09 ***	95.95 ***
Model II			
1 neighbor, no correction	-394.59 ***	73.95 ***	40.28
1 neighbor, correction	-399.90 ***	71.23 ***	42.43
3 neighbors, no correction	-134.25 **	103.28 ***	61.42 ***
3 neighbors, correction	-188.83 ***	99.26 ***	63.66 **

(continued)

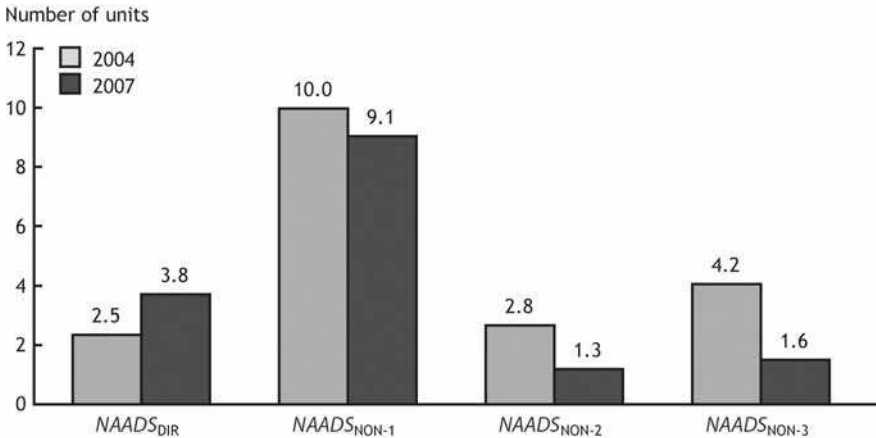
Table 5.16—Continued

Estimator/model	<i>ATT</i> <sub>NON-1</sub>	<i>ATT</i> <sub>NON-2</sub>	<i>ATT</i> <sub>NON-3</sub>
5 neighbors, no correction	-124.14 **	85.48 ***	69.57 ***
5 neighbors, correction	-176.04 ***	83.19 ***	72.67 ***
Model III			
1 neighbor, no correction	17.09 ***	90.37 ***	42.91
1 neighbor, correction	13.27 ***	80.91 **	43.04
3 neighbors, no correction	-150.05 **	89.36 ***	57.14 **
3 neighbors, correction	-207.41 ***	84.84 ***	59.57 **
5 neighbors, no correction	-129.00 **	84.97 ***	71.14 ***
5 neighbors, correction	-179.73 ***	81.76 ***	73.64 ***
2SWR (with covariates)			
Model I			
1 neighbor, no correction	-64.23 ***	80.34 ***	84.49 ***
1 neighbor, correction	-64.27 ***	69.79 ***	79.08 ***
3 neighbors, no correction	-219.84 ***	82.26 ***	71.17 ***
3 neighbors, correction	-218.76 ***	79.85 ***	66.82 ***
5 neighbors, no correction	-189.30 ***	87.73 ***	78.01 ***
5 neighbors, correction	-189.04 ***	84.35 ***	73.46 ***
Model II			
1 neighbor, no correction	-238.64 ***	64.58 ***	13.97
1 neighbor, correction	-231.36 ***	62.92 ***	13.71
3 neighbors, no correction	-189.46 ***	93.03 ***	32.39
3 neighbors, correction	-196.71 ***	85.61 ***	25.05
5 neighbors, no correction	-183.94 ***	79.04 ***	43.65 **
5 neighbors, correction	-193.55 ***	75.30 ***	37.41 *
Model III			
1 neighbor, no correction	-55.07 **	84.90 **	12.82
1 neighbor, correction	-65.06 ***	75.72 **	6.98
3 neighbors, no correction	-187.21 ***	81.32 ***	32.69
3 neighbors, correction	-189.17 ***	78.11 ***	26.15
5 neighbors, no correction	-152.58 ***	78.24 ***	47.55 **
5 neighbors, correction	-157.40 ***	74.54 ***	41.58 **

Source: Matched sample of treatment on nontreatment observations from NAADS-IFPRI 2004 and 2007 household surveys (panel).

Notes: ATT: average treatment effects on the treated. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). No correction versus correction for stratification, clustering, and weighting of the sample (see Table 5.14). \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Detailed 2SWR results for selected model specifications are presented in Appendix A (Table A.1).

**Figure 5.4—Number of extension visits received in 2004 and 2007, by treatment and control group**



Source: Matched sample of treatment on nontreatment observations from NAADS-IFPRI 2004 and 2007 household surveys (panel data).

large or very small and sometimes different in sign and statistical significance. This phenomenon is observed with the results to be presented as well as the results based on matching with 10 nearest neighbors, which is consistent with the literature saying that a greater number of matches generally increases precision but at the cost of increasing bias (Dehejia and Wahba 2002).

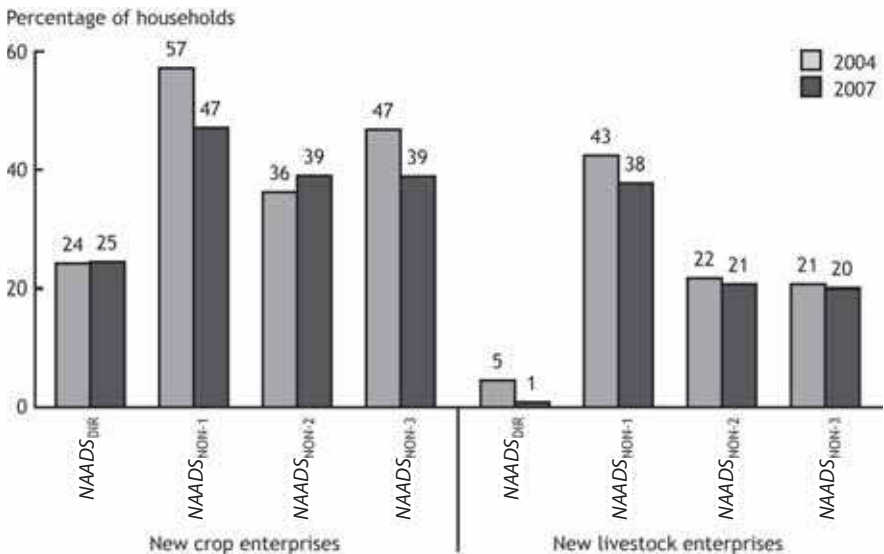
### ***Other Factors Affecting Change in Access to Advisory Services***

Detailed selected regression results are presented in Table A. 1. Looking across the regressions based on the different matched subsamples (i.e., matching NAADS<sub>DIR</sub> households separately with NAADS<sub>NON-1</sub>, NAADS<sub>NON-2</sub>, and NAADS<sub>NON-3</sub> households) and model specifications (i.e., Models I, II, and III), changes in gender, age, size, income source, and distance to infrastructure and other services had statistically significant associations with change in the number of extension visits received by a household. Change in gender of household head and increase in size of household were associated with an increased number of extension visits, whereas aging households and change in income sources were associated with decreased numbers. The latter is likely due to reduction in demand for services to the extent that changes in age and income reflect a shift away from agriculture. The negative and significant effect of the initial number of visits on the change in visits suggests that number of visitations declined across the board between 2004 and 2007.

### Adoption of New Enterprises

To assess the link between the NAADS program and adoption of new enterprises, in the surveys farmers were asked to provide information on any new crop, livestock, fishery, or beekeeping enterprise that they had adopted between 2000 and 2004 and between 2004 and 2007 in the 2004 and 2007 surveys, respectively. Looking at the adoption of new crop and livestock enterprises, Figure 5.5 shows a slight decline or no change in the proportion of households adopting new enterprises over time across the different groups. In general, the decline is expected to the extent that farmers may have settled on those enterprises that met their needs after having tried several alternatives. This is particularly expected of the direct participants in the NAADS program ( $NAADS_{DIR}$ ), although we did not observe the percentage adopting new enterprises at the start of their joining the program to verify the low percentages shown in Figure 5.5. Given that livestock production involves a longer-term commitment than most of the crop production activities undertaken by farmers, the lower percentages of households adopting new livestock enterprises across the different groups are expected.

**Figure 5.5—Percentage of households adopting new crop and livestock enterprises in 2004 and 2007, by treatment and control group**



Source: Matched sample of treatment on nontreatment observations from NAADS-IFPRI 2004 and 2007 household surveys (panel data).

### ***Impact of the NAADS Program on Change in Adoption of New Enterprises***

The second-stage panel probit results summarized in Table 5.17 are consistent with the previous descriptive results in the sense that participation in the NAADS program is generally not statistically and significantly associated with greater adoption of new crop or livestock enterprises in 2004 or 2007.

**Table 5.17—Panel random-effects probit regression results of the association between direct participation in the NAADS program and adoption of new crop and livestock enterprises in 2004 and 2007, by different control groups**

Estimator/model	New crop enterprises			New livestock enterprises		
	$ATT_{NON-1}$	$ATT_{NON-2}$	$ATT_{NON-3}$	$ATT_{NON-1}$	$ATT_{NON-2}$	$ATT_{NON-3}$
Two-stage weighted regression (2SWR) (without covariates)						
Model I						
1 neighbor	0.038	-0.092	0.157	0.137	-0.015	0.107
3 neighbors	-0.189	-0.174	0.179	-0.117	-0.181	-0.080
5 neighbors	-0.358 **	-0.110	0.109	-0.158	-0.162	-0.079
Model II						
1 neighbor	-0.071	-0.286 *	0.098	-0.280	-0.310	-0.196
3 neighbors	-0.200	-0.157	0.092	-0.065	-0.212	-0.110
5 neighbors	-0.230	-0.094	0.024	-0.018	-0.215	-0.095
Model III						
1 neighbor	0.107	0.040	-0.084	-0.046	-0.112	-0.172
3 neighbors	-0.176	-0.119	0.042	-0.148	-0.086	-0.015
5 neighbors	-0.286 *	-0.073	0.124	-0.169	-0.187	-0.017
2SWR (with covariates)						
Model I						
1 neighbor	0.112	-0.158	0.148	0.125	0.005	0.442
3 neighbors	-0.142	-0.235 *	0.281	-0.148	-0.225	-0.045
5 neighbors	-0.248 *	-0.152	0.202	-0.214	-0.197	0.010
Model II						
1 neighbor	0.118	-0.388 **	0.026	-0.422 *	-0.397 *	-0.110
3 neighbors	-0.080	-0.200	0.073	-0.042	-0.268	0.006
5 neighbors	-0.124	-0.152	0.098	-0.006	-0.267 *	0.008
Model III						
1 neighbor	0.418 *	0.007	-0.132	-0.034	-0.205	-0.045
3 neighbors	-0.089	-0.189	0.088	-0.139	-0.141	0.102
5 neighbors	-0.187	-0.148	0.136	-0.159	-0.258	0.104

Source: Matched sample of treatment on nontreatment observations from NAADS-IFPRI 2004 and 2007 household surveys (panel).

Notes: ATT: average treatment effects on the treated. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Detailed 2SWR results for selected model specifications are presented in Appendix A (Table A.2).

### **Other Factors Affecting Change in Adoption of New Enterprises**

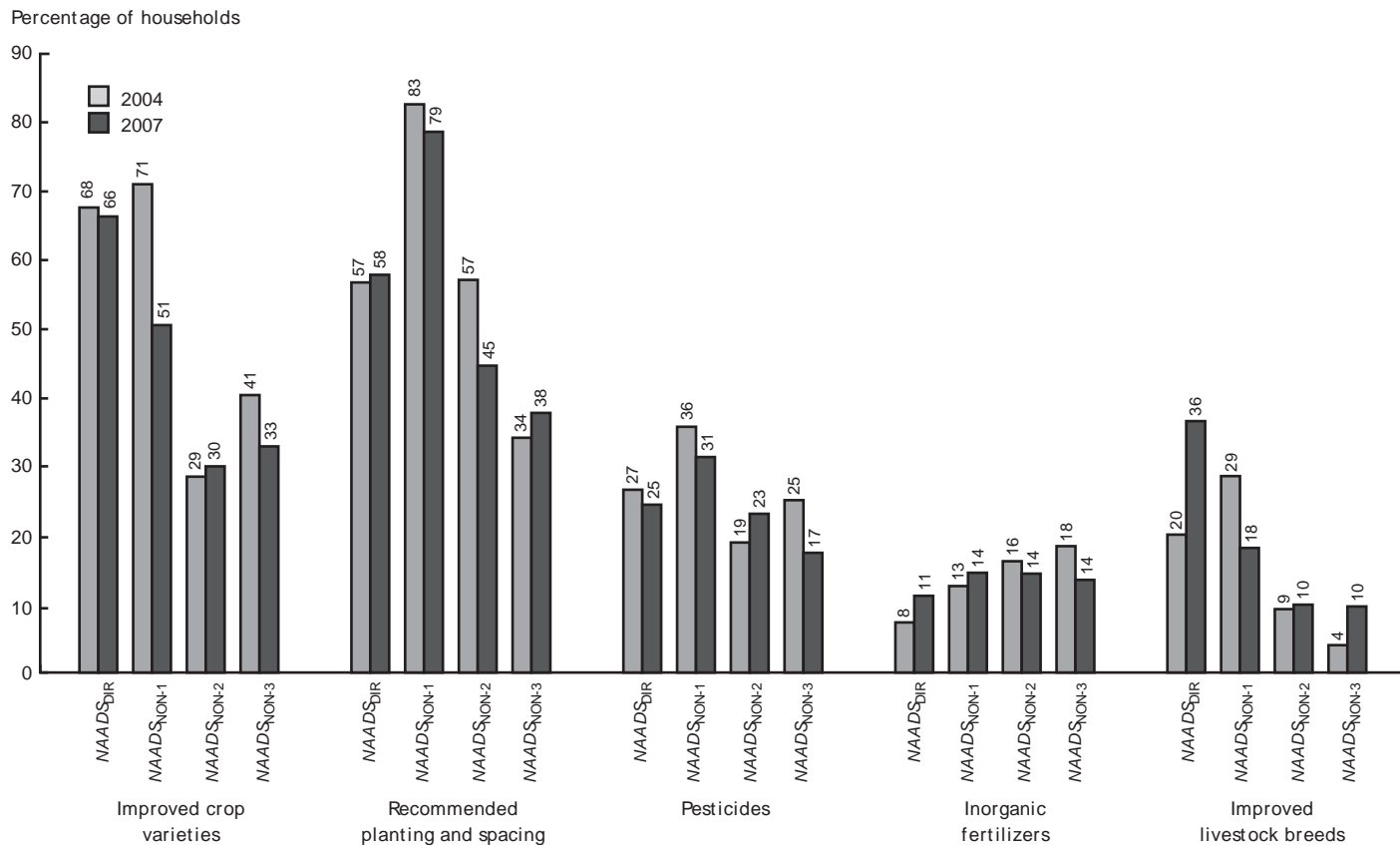
Detailed selected regression results are presented in Table A.2. Looking across the regressions based on the different matched subsamples and model specifications, age of household head and regional location were the only variables with the same sign and a statistically significant effect on the adoption of both new crop and livestock enterprises. Adoption was negatively associated with age, suggesting that younger people are more likely to adopt new enterprises. This makes sense, because older people are likely to be more efficient in their practices, requiring much greater returns to change their practices compared to younger and inexperienced farmers, who are just starting out and have lower marginal productivities. Regarding the other factors, female-headed households were associated with greater adoption of new livestock enterprises, particularly when  $NAADS_{DIR}$  households are compared with  $NAADS_{NON-3}$  households, that is, those located in areas where the program had never been implemented at the time of the surveys. More education, that is, having more postprimary-educated members, was significantly associated with greater adoption of both new crop and new livestock enterprises. Membership in other organizations was positively associated with adoption of new crop enterprises when  $NAADS_{DIR}$  households are compared with  $NAADS_{NON-1}$  and  $NAADS_{NON-2}$  households. Household income strategy was significant in adoption of crop enterprises, but only when  $NAADS_{DIR}$  households are compared with  $NAADS_{NON-3}$  households, whereas households located in other regions compared to those located in the Central Region were significantly associated with a lower likelihood of adopting new crop enterprises.

### **Adoption of Improved Production Technologies and Practices**

This section assesses the link between the NAADS program and adoption of improved agricultural production technologies and practices. Here we consider use of improved crop varieties, recommended planting and spacing practices, pesticides, inorganic fertilizers, and improved livestock breeds. The descriptive statistics based on the matched sample of treatment and nontreatment households from the 2004 and 2007 panel data are presented in Figure 5.6, whereas the second-stage results from estimating a panel-data random-effects probit model, for the same reasons mentioned earlier, are presented in Table 5.18.

Looking across the different technologies and practices, the results in Figure 5.6 show that improved crop varieties and recommended planting and spacing practices were the most commonly adopted in any year, followed by use of pesticides and then improved livestock breeds and inorganic fertilizers. Adoption of improved crop varieties, recommended planting and spacing practices, and improved livestock breeds was much more common

**Figure 5.6—Percentage of households adopting improved production technologies and practices in 2004 and 2007, by treatment and control group**



Source: Matched sample of treatment on nontreatment observations from NAADS-IFPRI 2004 and 2007 household surveys (panel data).

Note: TLU: Tropical livestock unit.

**Table 5.18—Panel random-effects probit regression results of the association between direct participation in the NAADS program and adoption of selected improved crop and livestock production technologies and practices in 2004 and 2007, by different control groups**

Estimator/model	Improved crop technologies			Recommended planting and spacing			Pesticides		
	$ATT_{NON-1}$	$ATT_{NON-2}$	$ATT_{NON-3}$	$ATT_{NON-1}$	$ATT_{NON-2}$	$ATT_{NON-3}$	$ATT_{NON-1}$	$ATT_{NON-2}$	$ATT_{NON-3}$
Two-stage weighted regression (2SWR) (without covariates)									
Model I									
1 neighbor	-0.068	0.245	0.054	-0.446**	0.087	0.184	-0.233	0.387**	-0.267
3 neighbors	-0.102	0.137	0.025	-0.408***	0.106	0.090	-0.287*	0.188	-0.177
5 neighbors	-0.196	0.150	-0.054	-0.418***	0.093	0.124	-0.283*	0.154	-0.197
Model II									
1 neighbor	-0.260	0.224	0.058	-0.455**	0.096	0.348*	-0.026	0.222	0.222
3 neighbors	-0.302*	0.152	0.026	-0.466***	0.106	0.311*	-0.214	0.154	-0.099
5 neighbors	-0.411**	0.173	-0.054	-0.486***	0.094	0.276*	-0.274*	0.090	-0.042
Model III									
1 neighbor	-0.135	0.414**	0.219	-0.510**	-0.125	0.250	-0.154	-0.023	0.159
3 neighbors	-0.315**	0.237*	0.026	-0.456***	-0.067	0.226	-0.256	-0.010	-0.055
5 neighbors	-0.350**	0.195	-0.037	-0.554***	0.021	0.265*	-0.261*	0.091	-0.102
2SWR (with covariates)									
Model I									
1 neighbor	0.112	0.111	0.192	-0.461**	0.044	0.199	-0.148	0.310	-0.333
3 neighbors	0.102	0.149	0.245	-0.333**	0.041	0.222	-0.188	0.141	-0.152
5 neighbors	-0.061	0.157	0.222	-0.371**	0.014	0.329*	-0.201	0.044	-0.177
Model II									
1 neighbor	-0.220	0.217	0.211	-0.640***	-0.021	0.403*	-0.034	0.100	0.233
3 neighbors	-0.245	0.121	0.232	-0.483***	0.006	0.389**	-0.132	0.097	-0.066
5 neighbors	-0.301**	0.160	0.200	-0.438***	-0.024	0.384**	-0.204	0.032	-0.028
Model III									
1 neighbor	-0.077	0.333*	0.434**	-0.345*	-0.194	0.256	-0.215	-0.173	0.180
3 neighbors	-0.194	0.238	0.309*	-0.415**	-0.125	0.351*	-0.244	-0.110	-0.009
5 neighbors	-0.226	0.195	0.226	-0.532***	-0.028	0.383**	-0.220	0.008	-0.056

(continued)

Table 5.18—Continued

Estimator/model	Inorganic fertilizers			Improved livestock breeds		
	$ATT_{NON-1}$	$ATT_{NON-2}$	$ATT_{NON-3}$	$ATT_{NON-1}$	$ATT_{NON-2}$	$ATT_{NON-3}$
2SWR (without covariates)						
Model I						
1 neighbor	0.001	-0.029	0.291	-0.098	0.133	0.241
3 neighbors	0.142	0.142	0.104	-0.152	-0.018	0.154
5 neighbors	0.006	0.112	0.079	-0.193	-0.002	0.231
Model II						
1 neighbor	0.223	0.290	0.073	-0.063	0.186	0.048
3 neighbors	0.090	0.071	0.153	-0.111	0.151	0.295
5 neighbors	0.005	0.076	0.125	-0.135	0.093	0.350
Model III						
1 neighbor	0.016	-0.063	0.291	-0.197	0.231	0.138
3 neighbors	-0.176	-0.028	0.153	-0.137	0.175	0.248
5 neighbors	-0.129	0.052	0.149	-0.143	0.134	0.256
2SWR (with covariates)						
Model I						
1 neighbor	-0.113	0.114	0.034	-0.066	0.152	0.010
3 neighbors	0.015	0.269	0.000	-0.079	0.036	0.080
5 neighbors	-0.105	0.219	0.000	-0.094	0.096	0.102
Model II						
1 neighbor	0.076	0.293	-0.009	-0.119	0.050	0.115
3 neighbors	-0.035	0.281	0.113	-0.080	0.081	0.134
5 neighbors	-0.106	0.209	0.183	0.001	0.065	0.162
Model III						
1 neighbor	-0.052	-0.162	0.285	-0.150	0.199	0.162
3 neighbors	-0.222	0.062	0.245	-0.125	0.185	0.185
5 neighbors	-0.247	0.133	0.000	-0.083	0.172	0.154

Source: Matched sample of treatment on nontreatment observations from NAADS-IFPRI 2004 and 2007 household surveys (panel).

Notes: ATT: average treatment effects on the treated. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Detailed 2SWR results for selected model specifications are presented in Appendix A (Table A.3).

for households participating directly ( $NAADS_{DIR}$ ) and indirectly ( $NAADS_{NON-1}$ ) in the NAADS program, whereas use of pesticides and inorganic fertilizer tended to be more equally adopted across the different groups. In terms of change between 2004 and 2007, the largest percentage changes occurred with adoption of improved livestock breeds, although the change was from relatively low incidence rates of adoption in 2004, with the percentage change increasing for direct participants ( $NAADS_{DIR}$ ) and nonparticipants in areas where the program was never implemented ( $NAADS_{NON-3}$ ), decreasing for indirect participants ( $NAADS_{NON-1}$ ), and remaining unchanged for nonparticipants in areas where the program was implemented ( $NAADS_{NON-2}$ ). Because of the relatively low incidence of adoption of pesticides and inorganic fertilizers in 2004, their percentage changes between 2004 and 2007 tended to be large. Other notable changes in adoption between 2004 and 2007 included decreases in adoption of improved crop varieties for  $NAADS_{NON-1}$  and  $NAADS_{NON-3}$  and a decrease in adoption of recommended planting and spacing for  $NAADS_{NON-2}$ .

#### ***Impact of the NAADS Program on Change in Adoption of Improved Technologies***

When other factors that are likely to affect the incidence of adoption are controlled for, the results in Table 5.18 show that direct participation is significantly associated only with greater use of recommended planting and spacing practices and when compared with nonparticipants in areas where the program was never implemented ( $ATT_{NON-3}$ ). The negative results obtained when compared with indirect participants ( $ATT_{NON-1}$ ) are consistent with  $NAADS_{NON-1}$  households' having greater access to extension in 2004 and 2007 (see Figure 5.4 and Table 5.16). The same pattern is observed for adoption of improved crop varieties, although the estimated coefficients are statistically significant only in a few of the model specifications.

Although the lack of statistical significance of direct participation in the NAADS program for adoption of new crop and livestock enterprises as well as adoption of improved agricultural technologies and practices is surprising and inconsistent with our theoretical predictions, it is not unreasonable. Adoption of these (e.g., improved seeds and livestock breeds, inorganic fertilizers, and pesticides), with the exception of recommended planting and spacing practices, requires farmers to have financial resources or credit facilities from which to acquire them. Therefore, the positive impact of the NAADS program found for adoption of recommended planting and spacing practices is not surprising because this may require only additional labor at most. The question is whether greater adoption of recommended planting and spacing practices is sufficient to drive the expected changes in subsequent outcome indicators, including increased productivity, commercialization of production, incomes, and welfare.

### **Other Factors Affecting Change in Adoption of Improved Technologies**

The detailed regression results presented in Table A.3 show that several factors besides participation in the NAADS program have contributed to the adoption by farmers of different improved agricultural technologies and practices. As with the previous outcomes analyzed, different factors have different effects on adoption of different technologies and practices, which also differ across the different matched subsamples and model specifications. Gender of the household head, for example, is a statistically significant factor only in the adoption of inorganic fertilizers and pesticides. We find that female-headed households were associated with a lower rate of adoption of pesticides across the board and with a lower rate of adoption of fertilizers when  $NAADS_{DIR}$  households are compared with  $NAADS_{NON-2}$  households only. Consistent with previous findings, age was generally negatively associated with adoption, although it was statistically significant only in the case of pesticides.

Education had positive associations with adoption of recommended planting and spacing practices, pesticides, and improved livestock breeds (particularly among the subsample with  $NAADS_{NON-3}$  households). Larger households and membership in other organizations were also associated with greater adoption, especially of improved crop varieties, recommended spacing and planting practices, pesticides, and improved livestock breeds, although there were differences across the different subsamples with direct and indirect participants. The positive association between household size and adoption of any of the technologies and practices is not surprising given the relatively large labor requirements for engaging in those activities.

The effect of primary sources of income and access to infrastructure and services was mixed. For example, better access to roads and markets was associated with greater likelihood of adoption of improved livestock breeds (among the subsample with  $NAADS_{NON-1}$  households) and inorganic fertilizers (with  $NAADS_{NON-2}$  households), respectively. As for the regional location of households, the likelihood of adopting improved technologies and practices was generally lower in the other three regions compared to the Central Region, except in the case of recommended spacing and planting practices; households in the Northern Region were the most likely to adopt them.

### **Crop and Livestock Productivity**

This section focuses on the impact of the NAADS program and other factors on crop and livestock productivity. Crop productivity was measured by the value of total crop output per acre of cultivated land, whereas livestock productivity was measured as the sum of change (i.e., gain or loss) in the value of the stock of animals and the value of products (milk, cheese, meat, etc.)

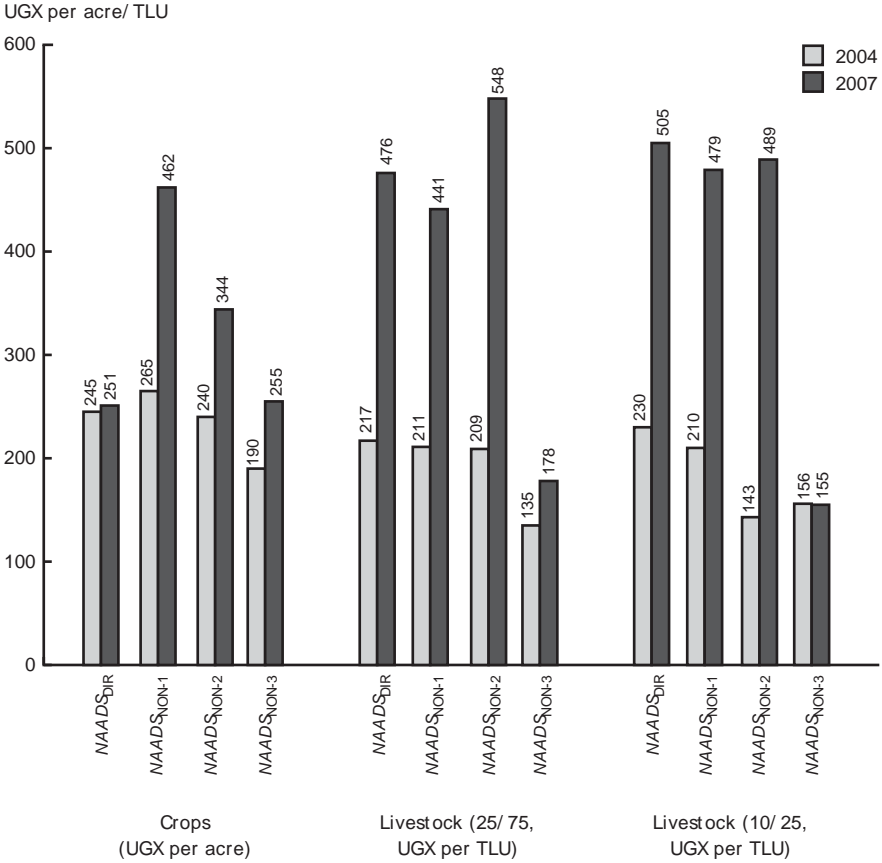
per tropical livestock unit (TLU).<sup>4</sup> The change in the value of the stock of animals was obtained over a four-year period (2000–04) in the 2004 survey and over a three-year period (2004–07) in the 2007 survey, so we divided the change by 4 and 3, respectively, to obtain the average gain in 2004 and 2007, respectively.<sup>5</sup> Information on livestock products was obtained only in the 2007 survey (where they constituted about 47 percent of the total), but farmers were asked to reveal their perception of the production in 2007 compared to 2004 in terms of whether production had increased a lot or a little, not changed, or decreased a little or a lot. Following the method used by Deininger (2003) in quantifying indicators based on qualitative responses, we called it a 75 percent increase (or decrease) in production if farmers responded that production had increased (or decreased) a lot, a 25 percent increase (or decrease) in production if farmers responded that production had increased (or decreased) a little, and zero if farmers responded that production had not changed. These percentages were used to estimate the value of livestock products in 2004. To assess the sensitivity of the results to using this method, we also used three other different combinations of percentages, including 10/ 25, 15/ 25, and 25/ 50. Descriptive statistics associated with the different livestock productivity indicators in 2004 are shown in Table 5.2. We find that the percentage differences associated with the minimum (i.e., using the 10/ 25 calculation) and maximum (using the 25/ 75 calculation) values for the different subgroups of nonparticipants, indirect participants, and direct participants are 10.6 percent, 4.5 percent, and 31.8 percent, respectively. This suggests that the *ATT* results could be sensitive to the choice of the measure of the livestock productivity indicator, particularly in the estimation of  $ATT_{DIR}$ . In presenting details of the estimation results, we focus on the low (10/ 25) and high (25/ 75) values of the measures used. Descriptive statistics are presented in Figure 5.7, whereas the estimated program impacts associated with the different model specifications and estimators are summarized in Table 5.19. Detailed selected regression results showing the effects of other factors are presented in Tables A.4 and A.5 for crop and livestock productivity, respectively.

The descriptive statistics presented in Figure 5.7 show that there was substantial increase between 2004 and 2007 in both crop and livestock productivity across the board, although the percentage increments were generally greater in the case of livestock productivity. For direct participants ( $NAADS_{DIR}$ )

<sup>4</sup> One TLU is equivalent to one cow, using the following conversion rates: 0.29 for pigs, 0.14 for sheep and goats, and 0.01 for poultry (based on Jahnke 1982).

<sup>5</sup> The change in the value of the stock of livestock was calculated as follows: ending stock plus the number born, sold, and given away less the number acquired and the beginning stock.

**Figure 5.7—Crop and livestock productivity in 2004 and 2007, by treatment and control group**



Source: Matched sample of treatment and control observations from NAADS-IFPRI 2004 and 2007 household surveys (panel data).

Notes: The 25/75 and 10/25 represent the combinations of percentages used in measuring the livestock productivity indicator. We do not expect the mean values of livestock productivity in 2007 to have been the same under the different combinations because the descriptive statistics were generated for the matched sample, which was determined based on the initial (or 2004) values of the explanatory variables, including livestock productivity.

**Table 5.19—Impact of the NAADS program on change in crop and livestock productivity between 2004 and 2007 (percentage difference between treatment [NAADS<sub>DIR</sub>] and different control groups)**

Estimator/model	Crop productivity			Livestock productivity (25/75)			Livestock productivity (10/25)		
	ATT <sub>NON-1</sub>	ATT <sub>NON-2</sub>	ATT <sub>NON-3</sub>	ATT <sub>NON-1</sub>	ATT <sub>NON-2</sub>	ATT <sub>NON-3</sub>	ATT <sub>NON-1</sub>	ATT <sub>NON-2</sub>	ATT <sub>NON-3</sub>
Propensity score matching (PSM)									
Model I									
1 neighbor	-18.6	-18.3	-50.0	-7.4	-13.3	206.2	-35.7	-59.4	192.7 *
3 neighbors	-35.7	-14.9	-58.5	0.7	12.2	197.9 *	-9.1	-18.7	215.2 **
5 neighbors	-44.7	-31.6	-56.3	-3.0	16.1	185.7 *	37.9	-1.3	206.3 *
Model II									
1 neighbor	-56.2	-109.3	-38.0	-23.8	-75.8	203.1	21.3	-23.4	287.7 *
3 neighbors	-62.1	-59.5	-52.2	6.4	-60.3	182.3	-6.9	-18.5	203.7 *
5 neighbors	-50.9	-44.3	-50.5	3.2	-52.4	178.0 *	30.7	-28.2	201.8 *
Model III									
1 neighbor	-57.7	-51.4	-13.8	-34.1	-22.5	323.8 *	24.8	72.7	170.9 *
3 neighbors	-46.4	-37.0	-39.7	-0.8	-51.1	246.3 **	21.0	5.4	229.3 *
5 neighbors	-42.5	-51.6	-45.5	5.2	-43.7	246.1 **	24.5	-22.0	200.5 *
Two-stage weighted regression (2SWR) (without covariates)									
Model I									
1 neighbor, NC	-9.4	-7.5	-18.1	-26.5	140.6	45.8	1.7	17.7	77.4
1 neighbor, C	-19.2	-12.3	30.6	-15.9	238.6 **	116.9 **	30.3	62.6	94.6
3 neighbors, NC	-24.6	-0.3	78.4	-21.4	67.2	42.1	-36.8	34.6	86.4
3 neighbors, C	-26.3	-8.3	148.8 *	2.7	132.0 *	79.7	-26.1	112.5	133.7 *
5 neighbors, NC	-30.0	23.4	52.2	-24.9	29.7	77.6	-28.5	31.7	140.7 **
5 neighbors, C	-35.7	13.6	99.7	1.7	105.7	129.3 **	-9.8	99.7 *	190.4 ***
Model II									
1 neighbor, NC	-31.5	161.6	53.9	-47.3	-30.7	178.1 **	9.1	19.9	56.8
1 neighbor, C	-31.8	190.6 *	159.6	-20.1	3.3	245.4 **	26.6	86.1	107.8
3 neighbors, NC	-26.5	44.0	84.5	-31.3	-35.1	158.3 **	-32.2	17.3	107.7 *
3 neighbors, C	-27.2	37.6	120.0	-8.7	-3.4	261.7 ***	-8.6	96.4	195.5 ***
5 neighbors, NC	-29.4	23.1	51.3	-33.9	-8.0	150.1 **	-31.6	6.6	106.1 *
5 neighbors, C	-30.2	14.2	73.5	-12.5	27.4	249.7 ***	-10.8	81.0	165.3 **

(continued)

Table 5.19—Continued

Estimator/model	Crop productivity			Livestock productivity (25/75)			Livestock productivity (10/25)		
	ATT <sub>NON-1</sub>	ATT <sub>NON-2</sub>	ATT <sub>NON-3</sub>	ATT <sub>NON-1</sub>	ATT <sub>NON-2</sub>	ATT <sub>NON-3</sub>	ATT <sub>NON-1</sub>	ATT <sub>NON-2</sub>	ATT <sub>NON-3</sub>
Model III									
1 neighbor, NC	-47.6**	26.9	162.8	-51.5**	-8.2	155.1*	-54.8*	35.8	54.1
1 neighbor, C	-43.1*	78.6	312.2*	-33.5	46.6	215.6**	-34.5	116.4	109.5**
3 neighbors, NC	-50.8***	-2.8	141.7	-48.7**	-16.8	132.7**	-39.1	9.8	190.6***
3 neighbors, C	-40.6*	0.2	190.2*	-31.9	31.7	216.4***	-13.8	41.1	280.5***
5 neighbors, NC	-23.2	-4.6	79.5	-37.3	-0.9	158.0**	-40.3	3.0	100.9*
5 neighbors, C	-21.1	-6.7	108.8	-17.1	41.2	254.9***	-27.2	44.4	179.9***
2SWR (with covariates)									
Model I									
1 neighbor, NC	-4.1	-16.5	-16.4	-40.0	145.5	9.5	-23.2	-1.2	76.7
1 neighbor, C	-11.6	-4.4	29.0	-36.6	217.7**	52.8	12.4	36.0	110.2
3 neighbors, NC	-22.8	-3.7	57.7	-12.8	52.3	23.6	-33.7	27.0	41.5
3 neighbors, C	-22.1	-1.1	106.7	4.2	93.8	54.9	-12.5	88.9	84.3
5 neighbors, NC	-18.2	26.0	49.0	-29.8	17.8	49.7	-30.6	12.5	89.7
5 neighbors, C	-22.7	18.9	75.6	-7.5	60.3	83.6	1.7	58.8	133.4*
Model II									
1 neighbor, NC	-36.5	132.0	79.2	-56.2*	-24.0	208.5	-9.8	22.4	51.6
1 neighbor, C	-36.0	154.9	201.6	-42.6	1.1	284.1**	-6.6	67.7	80.9
3 neighbors, NC	-33.4	35.1	72.6	-28.5	-27.4	144.0	-36.3	17.3	122.1
3 neighbors, C	-31.9	35.2	85.3	-8.9	-0.1	230.3**	-12.5	64.3	244.2**
5 neighbors, NC	-30.4	21.3	46.2	-32.0	-1.0	134.1	-36.7	2.3	85.0
5 neighbors, C	-30.6*	24.5	47.4	-11.0	30.7	217.8**	-8.7	47.6	150.6
Model III									
1 neighbor, NC	-48.8**	24.2	217.7*	-60.4**	25.2	110.7	-56.1	37.5	38.8
1 neighbor, C	-46.1**	76.1	344.4**	-56.9***	88.4	188.0	-35.9	118.6	85.2
3 neighbors, NC	-53.8***	-1.7	130.7*	-48.5*	-11.8	103.1	-49.8	7.6	166.3*
3 neighbors, C	-44.5**	9.5	140.5*	-38.4	33.8	166.4**	-26.0	29.0	250.7**
5 neighbors, NC	-18.7	-4.4	69.8	-36.4	-3.5	143.1*	-41.3	-2.7	83.0
5 neighbors, C	-14.3	-1.5	68.2	-19.7	36.9	231.4***	-15.1	27.5	167.1**

Source: Matched sample of treatment and nontreatment households from NAADS-IFPRI 2004 and 2007 household survey (panel data).

Notes: ATT: average treatment effects on the treated; NC and C: no correction and correction, respectively, for stratification, clustering, and weighting of sample (see Table 5.14). Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. The (25/75) and (10/25) represent the combinations of percentages used in measuring the livestock productivity indicator. Detailed 2SWR results for selected model specifications are presented in Appendix A (Tables A.4 and A.5).

we observe more than a doubling of livestock productivity between the two years, compared to only a 2 percent increase in crop productivity. Although  $NAADS_{NON-1}$  and  $NAADS_{NON-2}$  households realized large increases in crop and livestock productivities, those located in areas where the NAADS program was never implemented (i.e.,  $NAADS_{NON-3}$ ) realized relatively small increases in crop and livestock productivities, around 30 percent.

### ***Impact of the NAADS Program on Change in Productivity***

The estimated average treatment effects presented in Table 5.19 show that participation in the NAADS program had mostly positive impacts on change in crop and livestock productivity between 2004 and 2007, which tend to be more pronounced when direct participants ( $NAADS_{DIR}$ ) are compared to those located in areas where the NAADS program had never been implemented at the time of the 2007 survey ( $NAADS_{NON-3}$ ) (see the column of results headed  $ATT_{NON-3}$ ). This is in line with our expectations (i.e.,  $ATT_{NON-3} > ATT_{NON-2} > ATT_{NON-1}$ ) based on the assumption that direct participation in the program confers greater benefits than occasional contact with NAADS service providers or information. The results are also consistent with earlier findings associated with the subsample of  $NAADS_{DIR}$  versus  $NAADS_{NON-3}$  households, with the former having greater access to extension and a greater incidence of adoption of several technologies and practices in 2004 and 2007, particularly recommended planting and spacing practices in the case of crop production and, as we shall see in the next section, a greater increase in sales of livestock output. In the same vein, the negative and often statistically significant results obtained when direct participants are compared to indirect participants (i.e., the column of results headed  $ATT_{NON-1}$ ) is consistent with earlier findings, particularly that showing that  $NAADS_{NON-1}$  households had greater access to extension and a greater incidence of adoption of several technologies and practices in both 2004 and 2007.

The general trend of the results suggests that the NAADS program has had a greater average effect on livestock productivity than on crop productivity, which is consistent with our earlier finding that livestock enterprises were the most widely promoted of the different agricultural enterprises and technologies. Although participation in the program was not statistically significantly associated with greater adoption of improved livestock breeds (see Table 5.18), it was associated with a greater increase in sales of livestock products, as we shall see in the next section.

The estimates associated with the 2SWR without the covariates were generally larger in magnitude than those estimated with inclusion of the covariates, suggesting that not accounting for other factors affecting productivity overestimates the impact of the program. Comparing the results from the

different model specifications shows that using the different measures for the livestock productivity indicator had very little effect on the results. Whether the estimates were corrected for the sampling characteristics or not did not seem to matter much in terms of statistical significance with the 2SWR without the covariates. Regarding the 2SWR with the covariates, however, the correction gave rise to more statistically significant estimates. Here, too, we observe the U-shaped or inverted U-shaped nature of the results in relation to the different subsamples of nearest-neighbor matches. In general, the estimates associated with the subsample based on matching with a single nearest neighbor or 10 nearest neighbors (results not shown) tended to be very large or very small and sometimes different in sign and statistical significance, for reasons given earlier.

Given all this, in addition to the fact that the earlier results of Model III (i.e., inclusion of squared and interactions terms and excluding the length of the program) provided more common support, we place more confidence in the Model III results associated with the 2SWR with covariates corrected for the sampling characteristics and based on the subsample using the three and five nearest-neighbor matches. Thus the direct effect (i.e.,  $ATT_{\text{NON-3}}$ ) of the NAADS program on change in crop and livestock productivity between 2004 and 2007 could be up to 68.0–140.5 and 166.0–251.0 percent, respectively.<sup>6</sup> As we cautioned earlier, because of our inability to capture the separate effect of access to other or non-NAADS extension services, these may overestimate the impacts of the NAADS program to the extent that NAADS participants also benefited from other extension services. The same applies to the indirect impacts. This issue and inconsistencies across results for different impact indicators make it difficult to arrive at definitive conclusions regarding the direct and, particularly, the indirect impacts of the NAADS program.

### ***Other Factors Affecting Change in Crop Productivity***

Changes in other factors that significantly influenced change in crop productivity between 2004 and 2007 include changes in age of household head and in education and size of household (see Table A.4).<sup>7</sup> The negative and significant effect of the initial value of crop productivity on the change in productiv-

<sup>6</sup> The predicted impact associated with the NAADS indicator (as well as other discrete variables) on the productivity indicators can be calculated by taking the exponential of the relevant coefficient reported in the respective table in Appendix A, because the dependent variable is the logarithm of the value of the indicator. In particular, if the estimated coefficient is represented by  $\delta$ , then the ATT in percentage terms is given by  $(\exp(\delta) - 1) \times 100$ .

<sup>7</sup> In the appendix tables for these and other results, we report details of only the second-stage regression results based on the subsample using the three nearest-neighbor matches and excluding the potential endogenous explanatory variables (see Table 5.7 for the different model specifications).

ity suggests that crop productivity declined across the board between 2004 and 2007. Aging household heads and improvement in the education of the household were significantly associated with a decrease in crop productivity, whereas an increase in household size was associated with an increase, particularly among the subsample with  $NAADS_{NON-3}$  households. These findings reflect many of the earlier findings regarding the relationship between the factors and adoption of enterprises and technologies, particularly the negative relationship with age and the positive relationship with household size.

### ***Other Factors Affecting Change in Livestock Productivity***

Detailed selected regression results on the effects of factors on the change in livestock productivity are presented in Table A.5. Similar to the results of the general decline over time in crop productivity, livestock productivity compared to its initial value in 2004 declined over the period across the board. Regarding the other factors, only changes in education of the household and access to markets had statistically significant effects. Improvement in education had a negative effect among the subsample with  $NAADS_{NON-1}$  and  $NAADS_{NON-2}$  households, whereas a reduction had a positive effect among the subsample with  $NAADS_{NON-3}$  households. Increase in access to markets (i.e., reduction in distance to markets) had a positive effect (particularly among the subsample with  $NAADS_{NON-2}$  households).

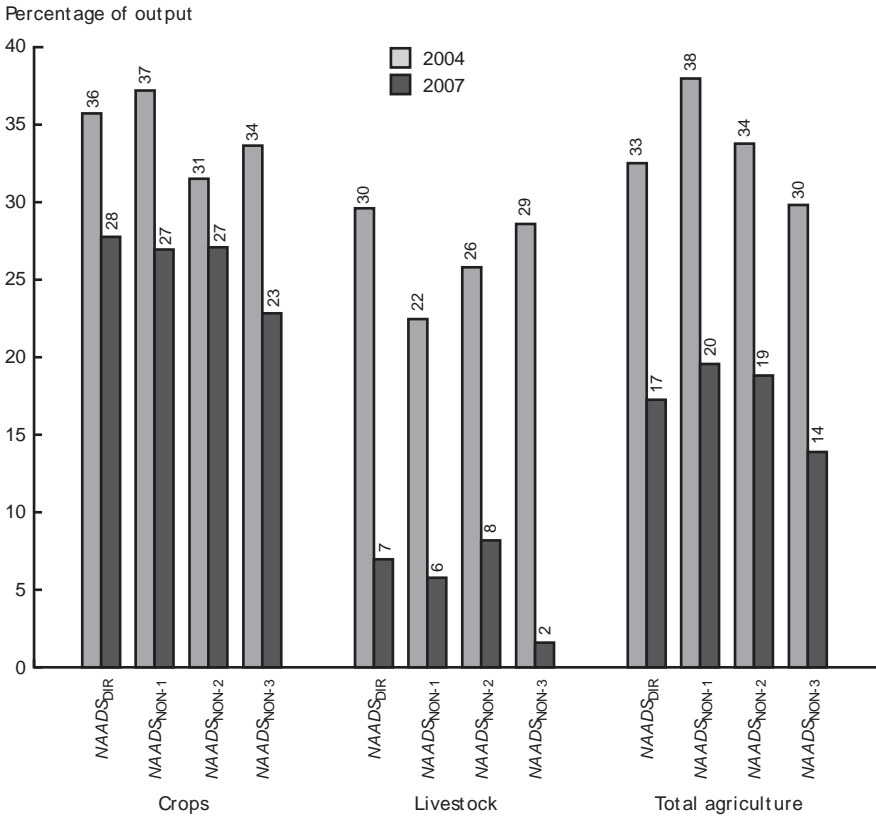
### **Commercialization of Agricultural Production**

Another important area that the NAADS program seeks to address is the low commercialization of agricultural production. We assessed the impact of the program and other factors on three indicators of agricultural commercialization: the percentages of crop output, livestock output, and total agricultural (crop, livestock, beekeeping, and aquaculture) output that were sold by farmers. Descriptive statistics of the shares of output sold by farmers in 2004 and 2007 are shown in Figure 5.8. We can see that the share of marketed output, particularly livestock, declined by a substantial margin across the board, although farmers located in areas where the program was never implemented (i.e.,  $NAADS_{NON-3}$ ) suffered the most in terms of percentage decrease. For example, the marketed share of livestock and livestock products declined by 94 percent for  $NAADS_{NON-3}$  and by 76, 74, and 68 percent for  $NAADS_{DIR}$ ,  $NAADS_{NON-1}$ , and  $NAADS_{NON-2}$  households, respectively.

### ***Impact of the NAADS Program on Change in Marketed Output***

The estimated program impacts are summarized in Table 5.20, and detailed selected regression results showing the effects of other factors are presented in Tables A.6–A.8. Table 5.20 reflects patterns similar to those described

**Figure 5.8—Percentage of crop, livestock, and total agriculture output sold by farmers in 2004 and 2007, by treatment and control group**



Source: Matched sample of treatment and control observations from NAADS-IFPRI 2004 and 2007 household surveys (panel data).

earlier regarding the estimates associated with the different model specifications, including estimation with and without the covariates, correction and no correction for the sampling characteristics, and the U-shaped or inverted U-shaped nature of the results in relation to the different subsamples of nearest-neighbor matches. Looking across the different subsectors, we see that the impacts of the NAADS program were greater in terms of sales of livestock and livestock products, with many of the relevant estimates across different model specifications statistically significant. These are particularly apparent when estimating the direct effects, that is, basing estimations on the subsample of direct participants ( $NAADS_{DIR}$ ) and those in areas where

**Table 5.20—Impact of the NAADS program on change in the percentage of agricultural output that was sold between 2004 and 2007 (difference between treatment [NAADS<sub>DIR</sub>] and different control groups)**

Estimator/model	Crops			Livestock			Total agriculture		
	ATT <sub>NON-1</sub>	ATT <sub>NON-2</sub>	ATT <sub>NON-3</sub>	ATT <sub>NON-1</sub>	ATT <sub>NON-2</sub>	ATT <sub>NON-3</sub>	ATT <sub>NON-1</sub>	ATT <sub>NON-2</sub>	ATT <sub>NON-3</sub>
Propensity score matching (PSM)									
Model I									
1 neighbor	2.01	5.78	22.14	22.97	-14.91	21.53	14.78	-0.28	21.95
3 neighbors	5.70	1.36	-0.89	-12.75	-3.68	31.19	12.84	-22.24	12.18
5 neighbors	7.10	9.11	2.36	3.46	0.31	23.80	12.56	-17.06	17.93
Model II									
1 neighbor	22.16	-4.56	7.24	-35.60	-9.80	34.08	-4.55	-5.90	21.51
3 neighbors	10.33	-4.62	15.32	-1.93	14.55	44.27	6.69	-2.69	14.50
5 neighbors	1.96	-5.18	15.15	1.64	9.97	28.69	4.23	-4.82	19.34
Model III									
1 neighbor	7.05	7.33	14.14	-78.50	-48.21	41.48	6.17	-7.37	21.19
3 neighbors	-2.29	-4.77	26.73	-33.20	-23.90	31.29	7.74	4.76	13.01
5 neighbors	-2.95	-4.42	18.29	-13.36	-17.48	26.70	6.55	1.20	17.94
Two-stage weighted regression (2SWR) (without covariates)									
Model I									
1 neighbor, NC	-3.08	-2.52	3.21	0.27	0.48	4.38	-3.88	0.08	-0.76
1 neighbor, C	-1.81	-6.45	12.62**	6.38	5.67	7.92	-2.04	2.94	5.91
3 neighbors, NC	-1.56	0.07	-0.35	-0.12	-0.84	0.49	-0.72	-0.35	2.78
3 neighbors, C	-3.32	0.20	5.29	5.21	5.75	2.43	0.86	2.45	8.38*
5 neighbors, NC	-0.08	0.43	-0.35	0.19	-0.05	1.60	-4.14	-1.09	-0.36
5 neighbors, C	-2.44	0.71	5.40	4.56	6.15	4.74	-4.92	0.62	4.38
Model II									
1 neighbor, NC	-4.50	-2.25	-1.92	-10.76	-0.64	3.83	-13.64**	0.45	0.11
1 neighbor, C	-6.28	-2.53	4.73	-10.60	5.11	11.82*	-9.03	2.85	5.04
3 neighbors, NC	-2.84	-1.48	-1.33	-3.98	0.34	5.07	-9.30**	-4.04	-4.88
3 neighbors, C	-6.69	-2.85	3.55	-1.25	5.68	10.86*	-7.42	-1.86	3.56
5 neighbors, NC	-5.19	-0.05	-0.76	-1.89	1.52	3.98	-5.74	-4.42	-2.13
5 neighbors, C	-7.59	-0.81	4.89	2.02	6.75	9.56	-3.86	-3.10	5.31

(continued)

Table 5.20—Continued

Estimator/model	Crops			Livestock			Total agriculture		
	ATT <sub>NON-1</sub>	ATT <sub>NON-2</sub>	ATT <sub>NON-3</sub>	ATT <sub>NON-1</sub>	ATT <sub>NON-2</sub>	ATT <sub>NON-3</sub>	ATT <sub>NON-1</sub>	ATT <sub>NON-2</sub>	ATT <sub>NON-3</sub>
Model III									
1 neighbor, NC	-0.94	4.08	3.94	-8.34	-0.09	5.70	-9.79	-2.29	4.93
1 neighbor, C	-4.10	5.25	8.63	-1.07	2.67	11.91**	-8.12	-2.67	9.55**
3 neighbors, NC	-0.56	1.14	2.29	-2.84	-0.09	6.16	-4.89	-1.76	0.53
3 neighbors, C	-3.62	2.23	6.25	0.96	3.96	12.08**	-4.36	0.03	5.54
5 neighbors, NC	0.33	2.42	0.08	-1.62	0.18	5.44	-3.27	-3.74	-1.53
5 neighbors, C	-3.50	3.20	2.58	1.86	5.15	10.62*	-0.92	-2.17	5.92
2SWR (with covariates)									
Model I									
1 neighbor, NC	0.69	-0.17	0.72	4.58	2.41	3.27	-0.63	-0.11	0.88
1 neighbor, C	2.37	-2.40	8.28	9.20*	6.60**	4.74	0.39	1.49	5.87
3 neighbors, NC	-0.58	-0.24	-1.48	2.78	1.57	-1.17	1.70	-0.54	1.99
3 neighbors, C	-1.18	0.67	2.85	7.12*	7.62***	-0.57	2.34	1.92	6.18*
5 neighbors, NC	1.87	0.18	-1.71	0.87	1.72	0.44	-3.54	-0.63	-1.27
5 neighbors, C	2.34	0.55	2.19	5.26	6.55**	2.45	-3.52	1.76	2.34
Model II									
1 neighbor, NC	0.19	2.09	-4.46	-6.39	3.77	0.01	-10.78*	1.47	-3.91
1 neighbor, C	1.40	2.92	1.61	-6.55	8.09***	4.96	-7.68	4.93	-0.70
3 neighbors, NC	0.92	-0.32	-2.32	-2.20	2.03	3.41	-6.88	-2.68	-6.96
3 neighbors, C	-1.12	-1.21	0.72	-2.34	5.19**	7.39**	-5.86	0.45	0.02
5 neighbors, NC	-3.58	0.36	-1.00	-1.30	3.22	1.61	-5.49	-3.53	-2.43
5 neighbors, C	-3.82	0.17	3.81	0.77	6.64**	5.71*	-3.26	-1.35	3.83
Model III									
1 neighbor, NC	-1.71	3.30	3.06	-2.39	0.12	3.46	-13.60*	-2.07	2.01
1 neighbor, C	-6.00	4.39	5.29	0.94	-0.76	8.75**	-13.71	-2.76	4.14
3 neighbors, NC	-1.11	-0.99	1.58	-3.42	2.13	3.69	-5.24	-1.55	-1.56
3 neighbors, C	-1.11	1.01	5.06	-0.09	3.61	7.82***	-6.13	0.38	2.14
5 neighbors, NC	0.96	1.39	0.18	-1.25	2.30	3.07	-4.50	-2.32	-2.60
5 neighbors, C	0.02	3.54	1.59	1.95	5.78**	6.56**	-2.15	0.15	3.21

Source: Matched sample of treatment and nontreatment households from NAADS-FPRI 2004 and 2007 household surveys (panel data).

Notes: ATT: average treatment effects on the treated; NC and C: no correction and correction, respectively, for stratification, clustering, and weighting of sample (see Table 5.14). Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Detailed 2SWR results for selected model specifications are presented in Appendix A (Tables A.6, A.7, and A.8).

the program was never implemented ( $NAADS_{NON-3}$ ) (see the column of results under livestock headed  $ATT_{NON-3}$ ). Based on our preferred model (i.e., Model III estimated by 2SWR with covariates, corrected for the sampling characteristics, and based on the subsample using the three and five nearest-neighbor matches), the direct effect of the program on change in the share of livestock output sold by farmers between 2004 and 2007 can be estimated to have been in the neighborhood of 8 percent.

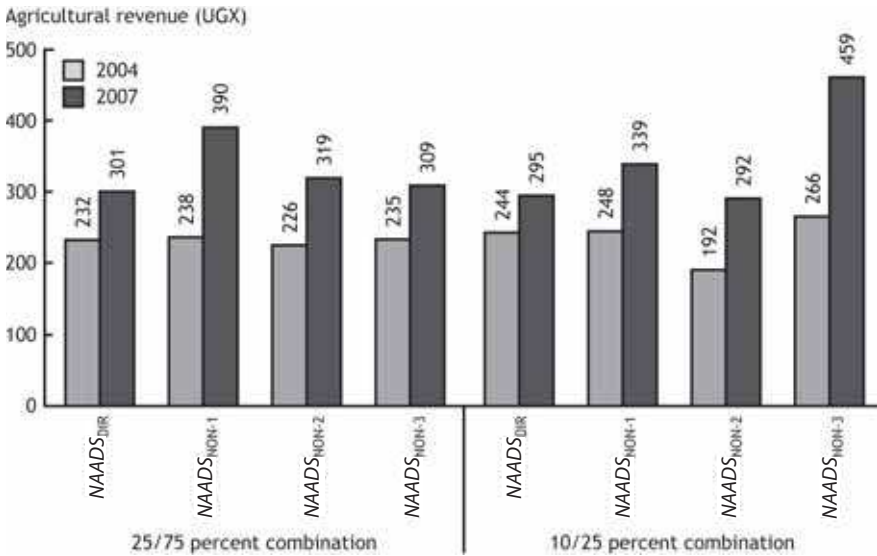
### ***Other Factors Affecting Change in Marketed Output***

Changes in other factors significantly influenced changes in the share of crop, livestock, and total agricultural output that was sold between 2004 and 2007, although the estimated effects differ across crops and livestock and also across different subsamples of participation (see Tables A.6–A.8 for details). For example, increase in the age of the household head was associated with an increase in the marketed share of livestock output but a reduction in the marketed share of crop and total output. Change in education was significant only in the regressions on the marketed share of livestock output, with mixed effects. Regarding the other factors, increase in household size was associated with a decrease in the marketed share of crop output but an increase in the marketed share of livestock output, particularly among the subsample with  $NAADS_{NON-1}$  households. Changes in income source and access to infrastructure had mixed associations. Improvements in access to all-weather roads and markets were associated with an increase in the marketed share of crop and total agricultural output. An improvement in access to credit, on the other hand, was associated with a decrease in the marketed share of crop, livestock, and total agricultural output. As with previous results, the negative and significant effect associated with the initial value of the share of marketed output suggests a decline in the share of marketed output between 2004 and 2007 across the board.

### **Agricultural Income**

Agricultural income is measured by agricultural gross revenue per adult equivalent (AE), which is the total value of crop, livestock, beekeeping, and aquaculture output divided by the total number of household members in terms of AEs. The issue of how livestock productivity was measured is still relevant here. Thus we also used agricultural revenue associated with the three different combinations of percentages introduced earlier (10/ 25, 15/ 25, and 25/ 50). The descriptive statistics for the extreme end of the combinations are shown in Figure 5.9. We see that the percentage changes between 2004 and 2007 are very close for the control groups in particular. The percentage increase in agricultural revenue was the least for the direct participants, about 21–30 percent. The percentage increases were 97–60, 41–52, and 32–72 percent for

**Figure 5.9—Agricultural revenue (UGX) per adult equivalent in 2004 and 2007, by treatment and control group**



Source: Matched sample of treatment and control observations from NAADS-IFPRI 2004 and 2007 household surveys (panel data).

Notes: We do not expect the mean values of livestock productivity in 2007 to have been the same under the different combinations because the descriptive statistics were generated for the matched sample, which was determined based on the initial (or 2004) values of the explanatory variables, including livestock productivity.

NAADS<sub>NON-1</sub>, NAADS<sub>NON-2</sub>, and NAADS<sub>NON-3</sub> households, respectively. Compared to the measures for livestock productivity, we see here that percentage differences associated with the minimum (i.e., using the 10/ 25 calculation) and maximum (using the 25/ 75 calculation) values for the different subgroups were much lower, suggesting that the *ATT* results associated with agricultural revenue are less likely to be sensitive to the choice of the measure of the livestock productivity indicator with the exception of NAADS<sub>NON-3</sub>, where the difference in the 2007 values is relatively larger, which has been confirmed.

**Impact of the NAADS Program on Change in Agricultural Revenue**

The estimated impacts associated with participation in the NAADS program are summarized in Table 5.21. The results are surprising given the general lack of statistical significance for *ATT*<sub>NON-3</sub>, that is, estimated treatment effects based on the subsample of direct participants (NAADS<sub>DIR</sub>) and those located in areas where the program was never implemented (NAADS<sub>NON-3</sub>), which is inconsistent with the earlier results, particularly on livestock pro-

**Table 5.21—Impact of the NAADS program on change in agricultural revenue per adult equivalent between 2004 and 2007 (percentage difference between treatment [ $NAADS_{DIR}$ ] and different control groups)**

Estimator/model	25/75 percent combination			10/25 percent combination		
	$ATT_{NON-1}$	$ATT_{NON-2}$	$ATT_{NON-3}$	$ATT_{NON-1}$	$ATT_{NON-2}$	$ATT_{NON-3}$
Propensity score matching (PSM)						
Model I						
1 neighbor	-1.60	31.42	-55.74	-29.33	-141.27 *	6.81
3 neighbors	-11.98	35.03	-37.26	-8.81	-75.19	4.14
5 neighbors	-34.78	32.90	-32.70	1.18	-42.48	0.38
Model II						
1 neighbor	-29.37	10.89	38.59	-35.17	14.82	-56.86
3 neighbors	-30.12	0.96	17.49	-34.98	-11.69	-20.04
5 neighbors	-19.43	5.89	-1.73	-29.26	-7.24	-14.02
Model III						
1 neighbor	-17.70	45.00	44.99	36.69	83.05	-26.03
3 neighbors	-17.17	22.54	15.08	-5.40	-2.38	-7.08
5 neighbors	-43.80	7.24	-22.77	-10.09	10.00	5.46
Two-stage weighted regression (2SWR) (without covariates)						
Model I						
1 neighbor, NC	-26.70	81.70 **	68.10	-24.90	0.90	3.40
1 neighbor, C	-14.00	106.70 ***	69.80	-23.60	8.20	14.60
3 neighbors, NC	-8.00	54.20 **	49.50	-34.90 *	14.90	31.80
3 neighbors, C	9.70	78.50 ***	48.30	-28.40	23.00	37.40
5 neighbors, NC	-35.40 *	35.40 *	16.70	-34.30 *	9.20	33.40
5 neighbors, C	-18.00	50.70 **	32.80	-23.20	15.70	50.70
Model II						
1 neighbor, NC	-55.20 **	32.30	59.70	-43.20	29.00	36.90
1 neighbor, C	-44.90 **	32.40	68.20	-30.30	52.10 *	35.30
3 neighbors, NC	-43.40 **	25.40	28.60	-40.60 **	37.40 *	34.60
3 neighbors, C	-30.50	24.10	35.70	-28.20	50.20 *	42.90
5 neighbors, NC	-40.60 **	24.60	47.90	-34.10 *	35.50 *	35.00
5 neighbors, C	-33.70	31.60	44.50	-16.70	45.00 *	48.90
Model III						
1 neighbor, NC	-27.60	44.50	95.90 **	0.00	91.00 ***	32.00
1 neighbor, C	9.30	59.90 *	90.30 *	-3.30	120.00 ***	69.70
3 neighbors, NC	-27.30	26.80	79.10 *	-26.00	52.20 **	37.60
3 neighbors, C	-5.00	47.50 *	64.40	-21.40	66.80 **	50.00
5 neighbors, NC	-35.00 *	23.30	56.80	-28.10	46.70 **	55.60
5 neighbors, C	-19.10	40.60 *	50.20	-21.10	59.60 **	65.70
2SWR (with covariates)						
Model I						
1 neighbor, NC	-25.90	98.40 ***	39.20	-9.80	18.80	-15.90
1 neighbor, C	-19.10	114.70 ***	26.40	12.30	19.00	-14.30
3 neighbors, NC	-4.70	75.60 ***	35.00	-23.30	28.50	11.30
3 neighbors, C	9.80	95.10 ***	17.30	-6.70	29.40	8.60
5 neighbors, NC	-26.10	48.00 **	-2.90	-27.90	16.20	6.50
5 neighbors, C	-5.80	61.70 **	-0.80	-10.70	21.80	10.90

(continued)

Table 5.21—Continued

Estimator/model	25/75 percent combination			10/25 percent combination		
	$ATT_{NON-1}$	$ATT_{NON-2}$	$ATT_{NON-3}$	$ATT_{NON-1}$	$ATT_{NON-2}$	$ATT_{NON-3}$
Model II						
1 neighbor, NC	-43.60*	44.80	52.40	-31.00	22.30	30.80
1 neighbor, C	-40.20*	33.20	74.70	-16.30	28.30	8.40
3 neighbors, NC	-34.00	31.00	16.40	-32.30	40.50*	5.90
3 neighbors, C	-23.70	31.20	25.50	-3.40	53.80**	-0.50
5 neighbors, NC	-37.80*	31.60	41.10	-26.50	41.00**	9.70
5 neighbors, C	-25.30	39.90	41.80	1.40	54.80**	6.80
Model III						
1 neighbor, NC	-21.80	43.00	85.00*	17.60	92.70***	25.30
1 neighbor, C	5.80	53.10*	69.70	12.10	123.80***	41.20
3 neighbors, NC	-24.50	39.20*	57.30	-26.30	49.60**	10.90
3 neighbors, C	-7.30	53.30**	30.50	-15.60	55.50**	1.80
5 neighbors, NC	-33.80*	32.40	41.40	-21.10	48.90**	28.40
5 neighbors, C	-10.40	48.10**	30.50	-13.10	59.30**	15.60

Source: Matched sample of treatment and control households from NAADS-IFPRI 2004 and 2007 household surveys (panel data).

Notes: ATT: average treatment effects on the treated; NC and C: no correction and correction, respectively, for stratification, clustering, and weighting of sample (see Table 5.14). Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. The 25/75 and 10/25 percent combinations represent the combination of percentages used in measuring the livestock productivity indicator. Detailed 2SWR results for selected model specifications are presented in Appendix A (Table A.9).

ductivity and sales. Here instead, it is  $ATT_{NON-2}$  that is mostly statistically significant across several of the model specifications, when previously it was not. The magnitudes of the estimated effects are also not consistently in line with our expectations (i.e.,  $ATT_{NON-3} > ATT_{NON-2} > ATT_{NON-1}$  does not always hold, particularly the first inequality). The mostly negative sign of  $ATT_{NON-1}$  is consistent with previous results, for the same reasons given. Some of the patterns of the estimates observed earlier, including direction, magnitude, and statistical significance, are different here. For example, using the 10/25 percent combination in estimating the livestock income component leads to smaller  $ATT_{NON-2}$  estimates for Models I and II but larger  $ATT_{NON-2}$  estimates for Model III. Other patterns observed earlier, such as larger estimates for 2SWR excluding the covariates and the serious sensitivity of the estimates to matching with one nearest neighbor, also apply here.

To investigate the inconsistency of the previous results compared to those obtained separately from estimation of crop and livestock productivity, we thought that changes in income from the different agricultural subsectors might be moving in opposite directions to the extent that they do not add up as one might expect. Figure 5.10 shows a plot of the crop and livestock productivity measures for the direct participants and different control groups. The figure suggests that indeed changes in income from crop and livestock sources between 2004 and 2007 rarely moved in the same direction. Although we control for change in the main income-generating activities (i.e., crops, livestock, etc.) of the households in our estimations, because of the enterprise-based approach of the NAADS program, change in the aggregate income measure is likely more challenging to explain with the type of matching done and the reduced-form model used here.

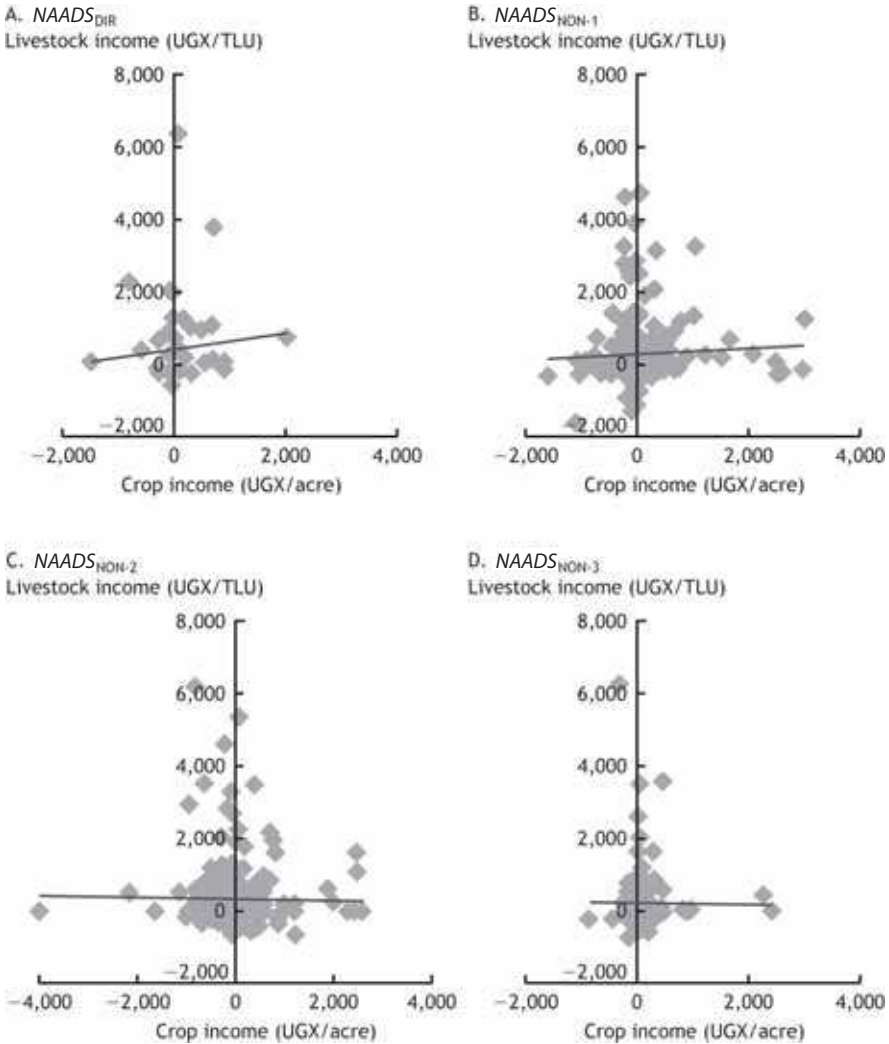
### ***Other Factors Affecting Change in Agricultural Revenue***

Detailed selected results on changes in other factors that influenced change in agricultural revenue per AE between 2004 and 2007 are shown in Table A.9. The main contributing factors were changes in sources of income and access to credit and all-weather roads. Compared to no change in source of income, the shift away from crop production activities had a negative association, whereas the shift away from livestock production activities had a positive association. Improvement in access to credit was associated with an increase in agricultural revenue across the board, whereas improvement in access to all-weather roads had mixed associations, positive for the subsample with  $NAADS_{NON-3}$  households but negative for the subsample with  $NAADS_{NON-2}$  households. The negative and significant effect associated with the initial value of agricultural revenue suggests a decline in agricultural revenue between 2004 and 2007 across the board.

### **Food and Nutrition Security and Overall Wealth**

In the two household surveys, farmers were asked to report their perception of how their households' food and nutrition security (i.e., access to food and nutritional quality of food) and average level of wealth had changed (increased, not changed, or worsened) between 2000 and 2004 and between 2004 and 2007. The descriptive statistics presented in Figure 5.11 show that the proportion of the direct participants ( $NAADS_{DIR}$ ) who perceived an improvement in their situation generally increased over time, whereas the proportions of the different control groups who perceived an improvement in their situation generally decreased over time, increased marginally, or remained unchanged. Although the proportions who perceived a worsening situation

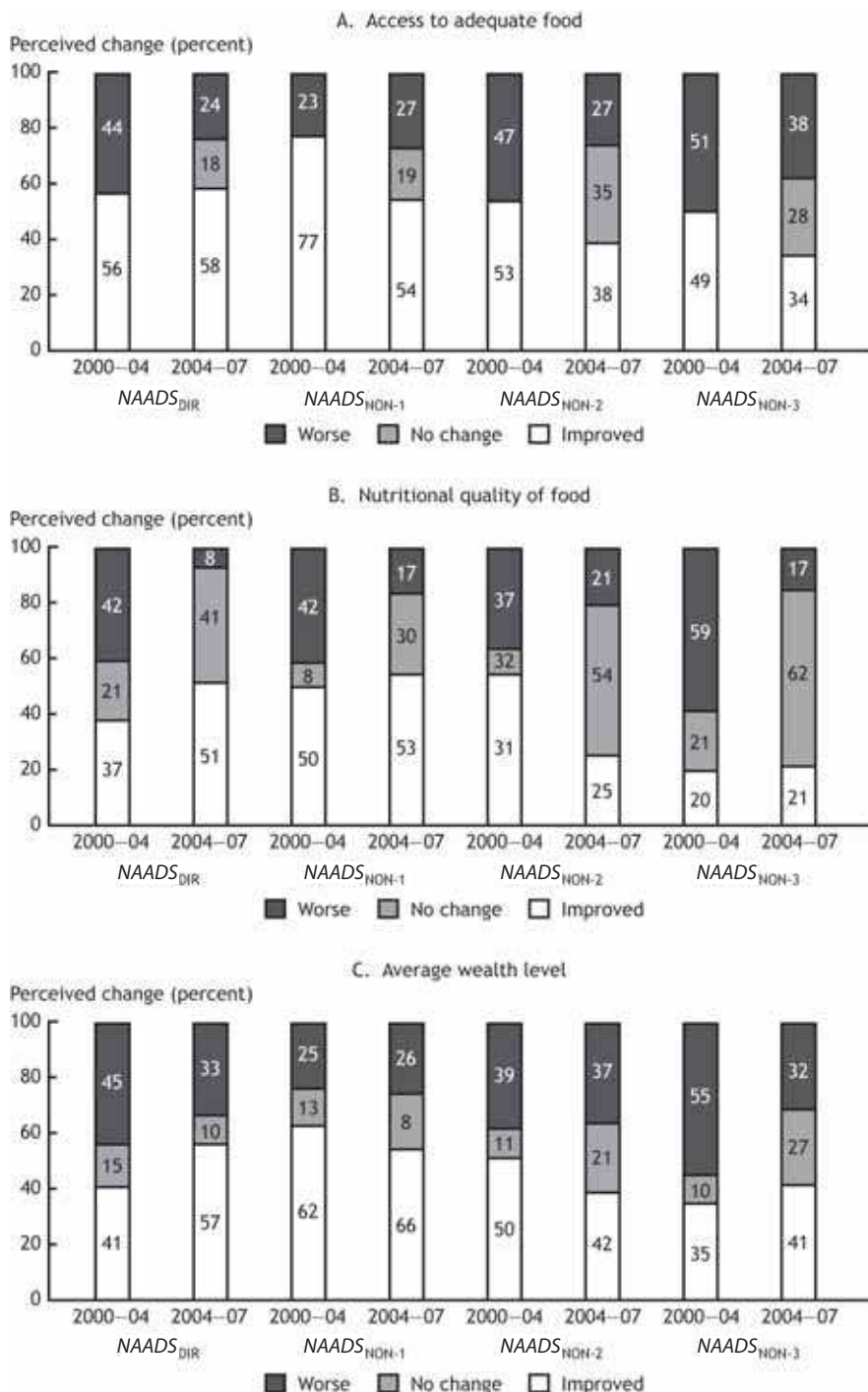
**Figure 5.10—Scatter plot of change between 2004 and 2007 in crop and livestock income, by treatment and control group**



Source: Matched sample of treatment and control observations from NAADS-IFPRI 2004 and 2007 household surveys (panel data).

Note: TLU: tropical livestock unit.

**Figure 5.11—Perception of changes between 2000 and 2007 in food and nutrition security and wealth, by treatment and control group**



Source: Matched sample of treatment and control households from NAADS-IFPRI 2004 and 2007 household surveys (panel data).

declined over time across the board, the proportions of the different control groups who perceived no change in their situation generally increased over time, with  $NAADS_{NON-2}$  and  $NAADS_{NON-3}$  households faring the worst. At least two-thirds of  $NAADS_{NON-2}$  and  $NAADS_{NON-3}$  households perceived a static or worsening situation in all three indicators in 2004–07.

To assess the impact of the NAADS program, we control for the initial values of the dependent variable and changes in other factors as presented in the methodology section. Unlike in the case of the adoption of improved technologies and practices, here there are multiple categories of the outcome indicator (i.e., increased, no change, and decreased). An appropriate estimator is the multinomial probit, which we use. The main issue for concern in this context is having adequate observations across the different categories for both direct participants and the control groups to reliably estimate the program's impact. This is problematic for many of the model specifications, particularly Models II and III, which involve estimating more coefficients, as well as for the  $NAADS_{NON-2}$  and  $NAADS_{NON-3}$  control groups, for which we have fewer numbers of observations to start with. Therefore, many of the impacts associated with these models could not be estimated, particularly for our preferred model specification. The results are summarized in Tables 5.22, 5.24, and 5.26, where the base category is no change. Consequently, we redefined the outcome indicators to be dichotomous under two different scenarios: first, taking on the value of one when the response was "improved" and zero otherwise, and second, taking on the value of one when the response was "worsened" and zero otherwise. Then we applied the regular probit estimator. Although this makes estimation easier, caution is required in interpretation of the resulting estimates because the base category combines two different perceived outcomes with potentially different underlying behaviors. The estimated impacts associated with these are summarized in Tables 5.23, 5.25, and 5.27. As before, selected detailed regression results for the multinomial probits are presented in Appendix A (see Tables A.10–A.12).

The results from the two estimators are consistent, and we see that direct participation in the NAADS program is generally positively associated with an improving situation and negatively associated with a worsening situation, particularly when participating households are compared with  $NAADS_{NON-2}$  and  $NAADS_{NON-3}$  households. Several of the estimated coefficients are statistically significant across different model specifications. Here, too, the seemingly negative impact of the program when the direct participants are compared with the indirect participants (i.e., the column of results headed  $ATT_{NON-1}$ ) is consistent with similar findings reported earlier and likely reflects better access to extension and confusion between NAADS service providers and other programs' agents. Together, the results are consistent with the increase

**Table 5.22—Panel random-effects multinomial-probit regression results of the association between direct participation in the NAADS program and perception of change in access to adequate food between 2004 and 2007, by different control groups**

Estimator/model	$ATT_{NON-1}$		$ATT_{NON-2}$		$ATT_{NON-3}$	
	Improved	Worsened	Improved	Worsened	Improved	Worsened
Two-stage weighted regression (2SWR) (without covariates)						
Model I						
1 neighbor	-0.027	-0.604	0.477	-0.225	0.605	0.059
3 neighbors	-0.186	-0.414	0.286	-0.570	0.694 *	-0.055
5 neighbors	-0.151	-0.636	0.403	-0.516	0.657	0.003
Model II						
1 neighbor	-1.154 **	-0.965*	0.225	0.049	0.532	-0.052
3 neighbors	-0.521	-0.876*	0.817 **	0.014	0.766 *	0.124
5 neighbors	-0.040	-0.301	0.810 **	-0.114	0.624	0.214
Model III						
1 neighbor	0.194	-0.251	0.408	-0.582	0.794	0.083
3 neighbors	0.226	-0.171	0.477	-0.449	0.707 *	0.232
5 neighbors	0.014	-0.153	0.580 *	-0.319	0.708 *	0.259
2SWR (with covariates)						
Model I						
1 neighbor	-0.089	-0.764	0.447	-0.234	0.651	-0.286
3 neighbors	-0.339	-0.815*	0.110	-0.779*	0.827 *	-0.303
5 neighbors	-0.249	-0.723	0.227	-0.715*	0.892 **	-0.269
Model II						
1 neighbor	-1.229 **	-1.220*	n.e.	n.e.	n.e.	n.e.
3 neighbors	-0.623	-0.776	0.825 **	-0.008	n.e.	n.e.
5 neighbors	-0.256	-0.338	0.730 **	-0.161	0.745	-0.216
Model III						
1 neighbor	-0.669	-1.421**	0.419	-0.355	n.e.	n.e.
3 neighbors	-0.236	-0.559	0.444	-0.455	n.e.	n.e.
5 neighbors	-0.277	-0.481	0.514	-0.359	0.895 *	-0.132

Source: Matched sample of treatment and control observations from NAADS-IFPRI 2004 and 2007 household surveys (panel data).

Notes: ATT: average treatment effects on the treated; n.e.: not estimated due to limited sample observations across categories of the dependent variable. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Detailed 2SWR results for selected model specifications are presented in Appendix A (Table A.10).

**Table 5.23—Panel random-effects probit regression results of the association between direct participation in the NAADS program and perception of change in access to adequate food between 2004 and 2007, by different control groups**

Estimator/model	<i>ATT</i> <sub>NON-1</sub>		<i>ATT</i> <sub>NON-2</sub>		<i>ATT</i> <sub>NON-3</sub>	
	Improved	Worsened	Improved	Worsened	Improved	Worsened
Two-stage weighted regression (2SWR) (without covariates)						
Model I						
1 neighbor	-0.068	0.101	0.185	0.071	0.276	-0.132
3 neighbors	-0.187	0.212	0.152	0.156	0.387**	-0.067
5 neighbors	-0.187	0.271	0.178	0.096	0.354**	-0.071
Model II						
1 neighbor	-0.101	0.563**	0.121	-0.059	0.184	0.122
3 neighbors	-0.164	0.356*	0.287**	-0.123	0.345*	-0.123
5 neighbors	-0.171	0.294*	0.233*	-0.052	0.318*	-0.164
Model III						
1 neighbor	-0.048	0.537**	0.306*	0.129	0.225	-0.055
3 neighbors	-0.146	0.275	0.133	0.098	0.323*	-0.131
5 neighbors	-0.194	0.328*	0.145	0.045	0.347*	-0.155
2SWR (with covariates)						
Model I						
1 neighbor	-0.036	0.268	0.073	-0.009	0.203	-0.160
3 neighbors	-0.095	0.273	0.110	0.176	0.334*	-0.162
5 neighbors	-0.083	0.369*	0.129	0.149	0.292	-0.181
Model II						
1 neighbor	-0.006	0.420	0.104	-0.161	0.091	0.148
3 neighbors	-0.095	0.382*	0.211	-0.104	0.264	-0.076
5 neighbors	-0.112	0.374*	0.171	-0.041	0.249	-0.199
Model III						
1 neighbor	-0.021	0.524*	0.301	0.154	0.063	-0.099
3 neighbors	-0.121	0.279	0.111	0.043	0.238	-0.133
5 neighbors	-0.173	0.377*	0.140	0.003	0.266	-0.170

Source: Matched sample of treatment and control observations from NAADS-IFPRI 2004 and 2007 household surveys (panel data).

Notes: ATT: average treatment effects on the treated. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance.

**Table 5.24—Panel random-effects multinomial-probit regression results of the association between direct participation in the NAADS program and perception of change in the nutritional quality of food between 2004 and 2007, by different control groups**

Estimator/model	ATT <sub>NON-1</sub>		ATT <sub>NON-2</sub>		ATT <sub>NON-3</sub>	
	Improved	Worsened	Improved	Worsened	Improved	Worsened
Two-stage weighted regression (2SWR) (without covariates)						
Model I						
1 neighbor	-0.005	0.346	0.516	-0.257	1.941***	-0.004
3 neighbors	0.197	0.194	0.723*	0.138	1.069**	-0.298
5 neighbors	0.229	0.349	0.899**	0.103	0.898*	-0.413
Model II						
1 neighbor	1.285 **	1.009	1.672***	1.194***	1.635***	0.210
3 neighbors	1.420 ***	1.012**	1.154***	0.527	1.368***	0.076
5 neighbors	1.131 **	0.717	0.884**	0.448	1.345***	0.226
Model III						
1 neighbor	-0.105	-0.243	1.186***	0.816*	1.515***	0.078
3 neighbors	0.588	0.435	1.030***	0.451	1.157***	0.195
5 neighbors	0.478	0.356	0.859**	0.400	1.002**	0.021
2SWR (with covariates)						
Model I						
1 neighbor	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
3 neighbors	0.560	0.316	0.806**	0.244	n.e.	n.e.
5 neighbors	0.411	0.448	0.947***	0.148	n.e.	n.e.
Model II						
1 neighbor	1.780 ***	1.268**	1.650***	1.191**	2.206***	1.256**
3 neighbors	1.441 ***	0.958**	1.039***	0.502	n.e.	n.e.
5 neighbors	1.278 ***	0.800*	0.971**	0.583	n.e.	n.e.
Model III						
1 neighbor	-1.719 *	-1.815*	1.306***	0.952**	n.e.	n.e.
3 neighbors	1.116 **	0.720	1.124***	0.519	n.e.	n.e.
5 neighbors	0.864 *	0.625	0.851**	0.400	n.e.	n.e.

Source: Matched sample of treatment and control observations from NAADS-IFPRI 2004 and 2007 household surveys (panel data).

Notes: ATT: average treatment effects on the treated; n.e.: not estimated due to limited sample observations across categories of the dependent variable. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Detailed 2SWR results for selected model specifications are presented in Appendix A (Table A.11).

**Table 5.25—Panel random-effects probit regression results of the association between direct participation in the NAADS program and perception of change in the nutritional quality of food between 2004 and 2007, by different control groups**

Estimator/model	<i>ATT</i> <sub>NON-1</sub>		<i>ATT</i> <sub>NON-2</sub>		<i>ATT</i> <sub>NON-3</sub>	
	Improved	Worsened	Improved	Worsened	Improved	Worsened
Two-stage weighted regression (2SWR) (without covariates)						
Model I						
1 neighbor	-0.186	0.080	0.206	-0.091	0.528**	-0.043
3 neighbors	-0.259*	0.121	0.116	0.054	0.332*	-0.002
5 neighbors	-0.225	0.084	0.133	0.044	0.374**	-0.023
Model II						
1 neighbor	-0.046	-0.015	0.287*	-0.184	0.244	-0.124
3 neighbors	-0.062	0.050	0.165	-0.038	0.409**	-0.131
5 neighbors	-0.088	0.049	0.124	-0.046	0.387**	-0.128
Model III						
1 neighbor	-0.138	0.109	0.158	-0.100	0.372*	-0.031
3 neighbors	-0.178	0.016	0.299**	-0.055	0.435**	-0.158
5 neighbors	-0.210	0.106	0.185	-0.056	0.396**	-0.108
2SWR (with covariates)						
Model I						
1 neighbor	-0.115	0.006	0.143	-0.146	0.421*	0.224
3 neighbors	-0.210	0.006	0.048	-0.012	0.256	0.244
5 neighbors	-0.169	0.033	0.073	-0.013	0.272	0.203
Model II						
1 neighbor	-0.015	-0.122	0.158	-0.194	0.270	0.089
3 neighbors	-0.086	-0.029	0.075	-0.100	0.331*	0.159
5 neighbors	-0.091	-0.007	0.079	-0.120	0.275	0.212
Model III						
1 neighbor	-0.125	0.234	0.045	-0.096	0.397*	0.031
3 neighbors	-0.181	-0.007	0.255*	-0.134	0.335*	0.186
5 neighbors	-0.180	0.043	0.143	-0.122	0.278	0.207

Source: Matched sample of treatment and control observations from NAADS-IFPRI 2004 and 2007 household surveys (panel data).

Notes: ATT: average treatment effects on the treated. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance.

**Table 5.26—Panel random-effects multinomial-probit regression results of the association between direct participation in the NAADS program and perception of change in average wealth between 2004 and 2007, by different control groups**

Estimator/model	<i>ATT</i> <sub>NON-1</sub>		<i>ATT</i> <sub>NON-2</sub>		<i>ATT</i> <sub>NON-3</sub>	
	Improved	Worsened	Improved	Worsened	Improved	Worsened
Two-stage weighted regression (2SWR) (without covariates)						
Model I						
1 neighbor	-0.749	-1.292**	0.489	-0.206	0.140	-0.805
3 neighbors	-0.075	-0.727	0.363	-0.404	0.313	-0.741
5 neighbors	-0.077	-0.660	0.341	-0.482	0.123	-0.728
Model II						
1 neighbor	-0.785	-1.412**	0.145	-1.008**	0.335	-0.544
3 neighbors	-0.411	-0.858	0.152	-0.778*	0.426	-0.405
5 neighbors	-0.059	-0.440	0.139	-0.745*	0.058	-0.378
Model III						
1 neighbor	-0.142	-0.722	-0.102	-0.947*	0.179	-0.740
3 neighbors	-0.316	-0.324	0.162	-0.713*	0.383	-0.370
5 neighbors	-0.056	-0.631	0.114	-0.638	0.201	-0.283
2SWR (with covariates)						
Model I						
1 neighbor	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
3 neighbors	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
5 neighbors	-0.029	-0.265	0.324	-0.313	0.175	-0.882*
Model II						
1 neighbor	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
3 neighbors	-0.149	-0.393	n.e.	n.e.	0.495	-0.686
5 neighbors	0.195	-0.031	0.003	-0.773*	0.050	-0.583
Model III						
1 neighbor	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
3 neighbors	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
5 neighbors	-0.269	-0.836	-0.056	-0.755*	0.190	-0.486

Source: Matched sample of treatment and control observations from NAADS-IFPRI 2004 and 2007 household surveys (panel data).

Notes: ATT: average treatment effects on the treated; n.e.: not estimated due to limited sample observations across categories of the dependent variable. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Detailed 2SWR results for selected model specifications are presented in Appendix A (Table A.12).

**Table 5.27—Panel random-effects probit regression results of the association between direct participation in the NAADS program and perception of change in average wealth between 2004 and 2007, by different control groups**

Estimator/model	$ATT_{NON-1}$		$ATT_{NON-2}$		$ATT_{NON-3}$	
	Improved	Worsened	Improved	Worsened	Improved	Worsened
Two-stage weighted regression (2SWR) (without covariates)						
Model I						
1 neighbor	-0.319*	0.310	-0.089	0.149	0.188	-0.116
3 neighbors	-0.288*	0.232	0.009	0.113	0.155	-0.057
5 neighbors	-0.217	0.155	-0.016	0.113	0.142	-0.073
Model II						
1 neighbor	-0.209	0.229	0.046	0.201	0.218	-0.131
3 neighbors	-0.196	0.237	-0.019	0.125	0.251	-0.109
5 neighbors	-0.182	0.195	0.023	0.102	0.102	-0.028
Model III						
1 neighbor	-0.388*	0.314	0.165	-0.008	0.207	-0.100
3 neighbors	-0.486***	0.426**	0.070	0.020	0.209	-0.109
5 neighbors	-0.391**	0.330**	0.039	0.027	0.135	-0.066
2SWR (with covariates)						
Model I						
1 neighbor	-0.210	0.192	-0.004	-0.014	0.103	-0.123
3 neighbors	-0.223	0.151	0.077	-0.072	0.125	-0.084
5 neighbors	-0.153	0.078	0.046	-0.051	0.129	-0.098
Model II						
1 neighbor	-0.182	0.188	0.192	0.038	0.171	-0.160
3 neighbors	-0.159	0.209	0.063	0.000	0.182	-0.080
5 neighbors	-0.146	0.150	0.089	-0.020	0.090	-0.043
Model III						
1 neighbor	-0.312	0.249	0.197	-0.046	0.208	-0.146
3 neighbors	-0.424**	0.352**	0.125	-0.106	0.146	-0.086
5 neighbors	-0.318*	0.272*	0.084	-0.088*	0.123	-0.077

Source: Matched sample of treatment and control observations from NAADS-IFPRI 2004 and 2007 household surveys (panel data).

Notes: ATT: average treatment effects on the treated. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance.

(about 9.5 percent) in the per capita consumption expenditure of Ugandans between 2002–03 and 2005–06 (Uganda, BOS 2006).

The detailed selected second-stage results presented in Tables A.10–A.12 show that different factors have contributed differently to changes in these outcomes, with differences across the different matched subsamples. Regarding change in access to food, for example, changes in gender of household head, size of household, income sources, and access to credit, roads, and markets were statistically significant factors. Regarding perception of change in nutritional quality of food, only changes in gender, household size, and access to credit and markets mattered. Perception of change in wealth was significantly influenced by changes in education and income sources.

### **Distribution of Program Effects and Factors Enhancing or Mitigating These Effects**

In this section we present the results of the estimations done to examine the distributional effects of the NAADS program as well as assess the factors that have enhanced or mitigated the effects of the program. As presented in the methodology chapter, this was done by re-estimating the *ATTs* associated with the value of crop output per acre, the value of livestock output per TLU, and agricultural revenue per AE using both the grouping and interaction approaches presented earlier. For the grouping approach, the regression is estimated separately for subsamples of categories of the explanatory variables, for example, male-headed and female-headed households (the results are presented in Table 5.28). The second approach includes in the regression a term of interaction between the NAADS participation variable and each of the other explanatory variables (the results are presented in Tables 5.29–5.31). For the grouping approach (Table 5.28), a positive (or negative) coefficient means that the impact of program is greater (or lower) within the relevant subcategory of the factor. Similarly, the coefficients can be compared across the subcategories, particularly where they are of the same sign. For the interaction approach (Tables 5.29–5.31), the interpretation has to be done in conjunction with the initial estimates vis-à-vis how the initial effects without the interactions have changed. However, basically, a positive (or negative) coefficient means that the impact of the program has been enhanced (or mitigated) by the change in the relevant factor. For both we used the Model III specification and matched subsamples based on three nearest-neighbor matches. For the interaction approach, however, we report only the detailed results associated with the subsample of  $NAADS_{DIR}$  and  $NAADS_{NON-3}$  households. As expected, different factors have contributed differently to enhancing or mitigating the effects of the program, which is shown by the differences in the signs, magnitudes, and levels of statistical significance

associated with estimated coefficients. We now discuss key findings associated with each of the factors considered, focusing mostly on the estimates that are statistically significant.

### **Gender**

Although inclusion of the term of interaction between the NAADS indicator and change in gender had no significant effect on the individual separate effects, the grouping approach shows that the estimated program impact was greater for male-headed households in the case of livestock productivity when  $NAADS_{DIR}$  households were compared with  $NAADS_{NON-1}$  households but lower in the case of crop productivity when they were compared with  $NAADS_{NON-1}$  households. Looking at total agricultural output, however, the estimated impact was greater among female-headed households when direct participants were compared with  $NAADS_{NON-1}$  households. Thus it seems that the NAADS program has so far been effective for men and women alike, although in different ways. That the majority of the extension providers in Uganda are men (about 88 percent) does not seem to have biased delivery of advisory services, although research shows that gender similarity between provider and receiver plays a major role in its effectiveness (Lahai, Goldey, and Jones 2000). The gender imbalance in service providers in Uganda is consistent with the general knowledge that women experience limited access to agricultural extension (e.g., see Staudt 1982; Alawy 1998; Adesina et al. 2000; Doss 2001). In SSA it has been estimated that only 7 percent of extension resources are spent on women; globally it is estimated that women receive only 2–10 percent of extension contacts and 5 percent of services (Swanson, Bentz, and Sofranko 1997).

### **Age, Education, and Household Size**

Inclusion in the estimation of terms of interaction between the NAADS indicator and these variables, particularly changes in age and education, is important for assessing the overall impact of the program, especially on crop productivity. The estimated average impact associated with the subsample with  $NAADS_{NON-1}$  households was lower for both younger and older household heads regarding crop and livestock productivity, respectively. Regarding income, it was larger when compared with  $NAADS_{NON-1}$  households and smaller for younger participants when compared with  $NAADS_{NON-2}$  households. For education we see greater impacts across all three categories (no formal schooling, completed primary education, and completed post-primary education) on crop and livestock productivity and agricultural revenue among the subsample with  $NAADS_{NON-2}$  and  $NAADS_{NON-3}$  households.

**Table 5.28—Distribution of the estimated impacts: Second-stage weighted regression estimates using the grouping approach**

Variable	Crop output (UGX per acre)			Livestock output (UGX per tropical livestock unit)			Agricultural output (UGX per adult equivalent [AE])		
	NAADS <sub>NON-1</sub>	NAADS <sub>NON-2</sub>	NAADS <sub>NON-3</sub>	NAADS <sub>NON-1</sub>	NAADS <sub>NON-2</sub>	NAADS <sub>NON-3</sub>	NAADS <sub>NON-1</sub>	NAADS <sub>NON-2</sub>	NAADS <sub>NON-3</sub>
Average effect	-0.590**	0.090	0.880*	-0.490	0.290	0.980**	-0.800	0.430**	0.270
Gender of head									
With variable									
Male	-0.528*	-0.135	0.867	-0.412	0.325	1.333**	-0.228	0.362	0.393
Female	-0.337	0.905	0.317	-6.905	-1.443	n.e.	0.875**	0.523	-0.461
Without variable									
Male	-0.528*	-0.135	0.867	-0.412	0.325	1.333**	-0.228	0.362	0.393
Female	-0.337	0.905	0.317	-6.905	-1.443	n.e.	0.875**	0.523	-0.461
Age of head									
With variable									
Older than 40 years	-0.623*	0.393	-0.066	-0.878	0.758	1.828	-0.222	0.673**	0.507
Age 40 years or younger	-0.561	0.053	1.120	-0.509*	0.152	-2.496	0.182	0.055	0.219
Without variable									
Older than 40 years	-0.740**	0.340	-0.057	-0.972	0.783	1.760	-0.285	0.642**	0.469
Age 40 years or younger	-0.471	0.040	1.822*	-0.529*	0.132	-1.131	0.182	0.010	0.113
Education									
With variable									
No formal	-1.050	0.872*	1.865	-4.538	-0.729	n.e.	-1.147	0.586	-3.984
Primary	-0.474	0.113	0.375	0.124	0.626	1.468*	-0.017	0.454*	0.460
Postprimary	-0.447	-0.565	0.136	-0.641	-0.735	n.e.	0.034	-0.333	0.790
Without variable									
No formal	-0.962	0.391	2.017	-3.102	-0.551	-4.230	-1.347	0.474	-1.382
Primary	-0.345	0.124	0.268	0.342	0.536	1.586**	0.037	0.450*	0.447
Postprimary	-0.207	-0.579	0.127	-0.591	-0.735	n.e.	0.020	-0.264	0.629

(continued)

Table 5.28—Continued

Variable	Crop output (UGX per acre)			Livestock output (UGX per tropical livestock unit)			Agricultural output (UGX per adult equivalent [AE])		
	NAADS <sub>NON-1</sub>	NAADS <sub>NON-2</sub>	NAADS <sub>NON-3</sub>	NAADS <sub>NON-1</sub>	NAADS <sub>NON-2</sub>	NAADS <sub>NON-3</sub>	NAADS <sub>NON-1</sub>	NAADS <sub>NON-2</sub>	NAADS <sub>NON-3</sub>
Household size									
With variable									
More than 5 AEs	-0.784*	-0.183	-0.010	-0.536	0.215	1.586	-0.165	0.501	0.962*
5 or fewer AEs	-0.660*	0.133	1.642	-0.152	0.298	-0.572	-0.097	0.104	-0.998
Without variable									
More than 5 AEs	-0.815**	-0.171	0.041	-0.589	0.193	1.567	-0.171	0.553*	1.046*
5 or fewer AEs	-0.778**	0.121	1.573	-0.092	0.305	-0.680	-0.057	0.076	-0.817
Income strategy									
With variable									
Crops	-0.635**	-0.416	1.549**	-0.686	0.622	1.508*	-0.390	0.091	0.196
Livestock	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
Other agriculture	n.e.	1.342	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
Nonagriculture	-1.100**	0.355	0.613	-0.324	-0.130	1.158	0.421	1.152**	-0.195
Without variable									
Crops	-0.635**	-0.431	1.596**	-0.638	0.634	1.348	-0.397	0.107	0.018
Livestock	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
Other agriculture	n.e.	1.342	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.
Nonagriculture	-1.068**	0.305	0.649	-0.377	-0.185	1.237	0.408	1.076**	-0.357
Land owned									
More than 1 acre	-0.015	0.586	0.192	-1.089	0.942	1.973**	-0.216	0.185	0.282
1 acre or less	-0.899**	0.095	0.727	0.064	-0.105	0.390	0.197	0.569**	0.499
Productive assets									
Tercile 1	-0.506	0.390	0.584	1.237	1.428*	n.e.	-0.021	0.455	-0.577
Tercile 2	-0.892**	-0.803	1.281	0.014	-1.131	-0.158	0.369	0.196	0.908*
Tercile 3	-0.460	0.275	0.748	-1.950	-0.533	-0.749	-0.929*	0.234	0.104

Distance to credit									
With variable									
More than 10 km	-0.229	0.253	1.337*	-0.490	0.391	1.319*	-0.408	0.438	0.092
10 km or less	-1.104***	-0.441	-1.159*	0.146	0.066	n.e.	0.873**	0.127	-0.193
Without variable									
More than 10 km	-0.196	0.231	1.358*	-0.488	0.408	1.420***	-0.407	0.435	0.410
10 km or less	-1.105***	-0.441	-1.140**	-0.015	0.075	n.e.	0.861**	0.161	-0.189
Distance to road									
With variable									
More than 0.5 km	-0.398	0.540	0.031	-0.685	-0.282	0.545	-0.377	0.412*	-0.012
0.5 km or less	-0.700	-0.602	1.851	-0.500	1.222 *	0.740	0.859*	0.167	1.376 **
Without variable									
More than 0.5 km	-0.404	0.526	0.314	-0.686	-0.330	0.581	-0.384	0.413*	-0.034
0.5 km or less	-0.724	-0.638*	1.815	-0.500	1.191	0.740	0.762	0.013	1.422 **
Distance to markets									
With variable									
More than 5 km	-0.511	0.307	1.411***	-0.655	0.256	1.765*	-0.080	0.538*	0.813 *
5 km or less	-0.589*	-0.250	-0.066	0.454	-0.085	-0.375	-0.227	0.207	-0.238
Without variable									
More than 5 km	-0.513	0.304	1.396***	-0.698	0.229	1.742*	-0.146	0.538*	0.813 *
5 km or less	-0.585*	-0.271	-0.044	0.358	-0.130	-0.056	-0.288	0.208	-0.366
Region									
Central	-0.785	0.062	1.160	n.e.	n.e.	n.e.	0.423	-0.280	-0.002
Eastern	0.574	0.690	0.448	2.387	-0.046	0.747	1.074	0.889***	0.194
Northern	-0.476	0.791	n.e.	1.036	0.757	n.e.	0.291	0.316	n.e.
Western	-0.218	-0.436	-0.675	-0.701	-0.754	-0.619	-0.247	0.279	-0.028

Source: Matched sample of treatment and nontreatment households from NAADS-IFPRI 2004 and 2007 household survey panel data; based on Model III (see Table 5.7) and three nearest neighbor matches.

Notes: See Tables 5.1 and 5.2 for a detailed description of the variables. The treatment group in each case is  $NAADS_{DIR}$ . With and without variable: inclusion or exclusion of the variable in the second-stage regression; n.e.: not estimated due to lack of observations. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance.

**Table 5.29—Distribution of the estimated impacts: Second-stage weighted regression estimates using the interaction terms approach, crop output (UGX per acre)**

Explanatory variable	Including interaction with								
	Initial	Gender	Age	Education	Household size	Income source	Access to credit	Access to roads	Access to markets
NAADS	0.88*	0.88*	0.47	0.91	0.97**	1.78**	0.88*	0.82*	0.88*
Δ gender of head	-0.29	0.23	-0.47	-0.34	-0.29	-0.06	-0.27	-0.28	-0.29
Δ In age of head	-2.58*	-2.48*	-4.82*	-2.08	-3.47**	-2.65**	-2.57*	-2.60**	-2.57*
Δ education (cf. no change)									
Reduction	-2.48*	-2.51*	-1.86	-3.99*	-2.17**	-2.73**	-2.49*	-2.46*	-2.49*
Improvement	-0.47	-0.44	-0.36	1.32	-0.21	-0.35	-0.48	-0.45	-0.48
Δ In household size	1.36**	1.35**	1.70**	1.42**	2.34**	1.57***	1.37**	1.38**	1.36**
Δ Income source (cf. no change)									
Crops to other sources	1.33*	1.33*	1.16*	1.37**	1.05*	2.45***	1.33*	1.37*	1.33*
Livestock to other sources	1.83	1.83	1.70*	1.14	1.33	0.71	1.83	1.90	1.82
Other agriculture to other sources	-0.69	-0.70	-0.49	-0.76	-0.42	-0.39	-0.70	-0.72	-0.70
Nonfarm activities to other sources	0.57	0.63	0.63	0.69	0.86	1.94**	0.57	0.57	0.56
Δ In distance to service									
Credit	-0.25	-0.22	-0.28	-0.26	-0.04	-0.42	-31.27	-0.62	-0.34
All-weather road	1.84**	1.81**	1.94**	1.72**	1.74**	1.95**	1.85**	1.08**	1.85**
Markets	0.21	0.20	0.30	0.18	0.20	0.37	1.22	0.22	0.15
In crop output_2004	-0.66***	-0.65***	-0.66***	-0.68***	-0.66***	-0.63***	-0.65***	-0.63***	-0.65***

NAADS × $\Delta$ gender of head		-1.18							
NAADS × $\Delta$ ln age of head			4.69						
NAADS × $\Delta$ education									
NAADS × reduction				2.82					
NAADS × improvement				-3.06***					
NAADS × $\Delta$ ln household size									
NAADS × $\Delta$ income source									
NAADS × crops to other sources									-2.26**
NAADS × livestock to other sources									2.56
NAADS × other agriculture to other sources									-0.12
NAADS × nonfarm to other sources									-2.89**
NAADS × $\Delta$ ln distance to service									
NAADS × credit									30.94
NAADS × all-weather road									2.33
NAADS × markets									1.16
Intercept	6.74***	6.70***	7.00***	6.91***	6.75***	6.05***	6.68***	6.46***	6.68***
R-squared	0.53	0.53	0.55	0.56	0.57	0.58	0.53	0.53	0.53

Source of data: Matched sample of treatment and nontreatment households from NAADS-IFPRI 2004 and 2007 household survey panel data; based on Model III (see Table 5.7) and three nearest neighbor matches.

Notes: See Tables 5.1 and 5.2 for a detailed description of the variables. The treatment group in each case is  $NAADS_{DIR}$ . ln: transformation by natural logarithm;  $\Delta$ : change between 2004 and 2007 values. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Elsewhere, blank cells mean not applicable.

**Table 5.30—Distribution of the estimated impacts: Second-stage weighted regression estimates using the interaction terms approach, livestock output (UGX per tropical livestock unit)**

Explanatory variable	Including interaction with								
	Initial	Gender	Age	Education	Household size	Income source	Access to credit	Access to roads	Access to markets
NAADS	0.98 **	0.98 **	1.00 **	1.10 *	1.18 **	0.87	1.15 **	1.21 **	1.02 **
Δ gender of head	-0.18	0.37	-0.02	-0.07	-0.34	-0.36	-0.03	0.02	-0.21
Δ In age of head	-0.31	-0.33	-1.32	0.27	-0.66	0.01	0.27	-1.17	-0.61
Δ education (cf. no change)									
Reduction	1.05 **	1.06 **	1.07 **	0.83 **	1.07 **	0.92 **	0.99 **	1.16 ***	1.04 **
Improvement	-0.65	-0.65	-0.93	0.75	-0.59	-0.56	-1.20	-1.16	-0.87
Δ In household size	0.95 **	0.93 *	1.23 **	1.16 **	1.48 **	0.87 *	1.15 **	1.10 **	1.00 **
Δ Income source (cf. no change)									
Crops to other sources	-0.41	-0.41	-0.39	-0.41	-0.49	-1.23	-0.31	-0.68	-0.39
Livestock to other sources	0.23	0.23	0.41	0.26	0.44	0.17	0.29	0.41	0.27
Other agriculture to other sources	-0.38	-0.37	-0.48	-0.54	-0.28	-0.23	-0.49	-0.65	-0.45
Nonfarm activities to other sources	-0.68	-0.70	-0.70	-0.84 *	-0.67	-0.72	-0.81 *	-0.58	-0.73 *
Δ In distance to service									
Credit	-1.24	-1.26	-1.09	-1.11	-0.94	-1.38	-4.94	-1.13	-1.34
All-weather road	-11.42	-11.93	-17.50	-15.74	-12.30	-20.32	-14.94	-30.47	-6.54
Markets	-0.44	-0.41	-1.31	-1.19	-1.39	-0.64	-1.27	0.04	-18.55
In crop output_2004	-0.58 ***	-0.59 ***	-0.58 ***	-0.55 ***	-0.61 ***	-0.63 ***	-0.55 ***	-0.55 **	-0.59 ***

NAADS × $\Delta$ gender of head		-2.07 ***							
NAADS × $\Delta$ ln age of head			1.98						
NAADS × $\Delta$ education									
NAADS × reduction				0.34					
NAADS × improvement				-1.89					
NAADS × $\Delta$ ln household size						-0.95			
NAADS × $\Delta$ income source									
NAADS × crops to other sources							1.14		
NAADS × livestock to other sources								n.e.	
NAADS × other agriculture to other sources									n.e.
NAADS × nonfarm activities to other sources									-0.06
NAADS × $\Delta$ ln distance to service									
NAADS × credit							3.89		
NAADS × all-weather road								38.82	
NAADS × markets									18.59 *
Intercept	7.05 ***	7.08 ***	6.91 ***	6.58 ***	7.26 ***	7.59 ***	6.54 ***	6.58 **	7.16 ***
R-squared	0.46	0.47	0.47	0.47	0.46	0.47	0.47	0.47	0.46

Source of data: Matched sample of treatment and nontreatment households from NAADS-IFPRI 2004 and 2007 household survey panel data; based on Model III (see Table 5.7) and three nearest neighbor matches.

Notes: See Tables 5.1 and 5.2 for a detailed description of the variables. The treatment group in each case is  $NAADS_{DIR}$ . ln: transformation by natural logarithm;  $\Delta$ : change between 2004 and 2007 values. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Elsewhere, blank cells mean not applicable.

**Table 5.31—Distribution of the estimated impacts: Second-stage weighted regression estimates using the interaction terms approach, agricultural revenue (UGX per adult equivalent)**

Explanatory variable	Including interaction with								
	Initial	Gender	Age	Education	Household size	Income source	Access to credit	Access to roads	Access to markets
NAADS	0.27	0.26	0.41	0.19	0.04	0.54	0.29	0.18	0.26
Δ gender of head	0.56	0.50	0.67*	0.56*	0.40	0.70*	0.57	0.47	0.56
Δ In age of head	-0.24	-0.27	1.28	-0.30	0.17	-0.21	-0.15	-0.09	-0.26
Δ education (cf. no change)									
Reduction	0.37	0.37	0.49	0.41	0.33	0.33	0.37	0.44	0.37
Improvement	-0.33	-0.34	-0.20	-0.59	-0.30	-0.31	-0.38	-0.36	-0.32
Δ In household size	-0.49	-0.50	-0.77**	-0.49	-1.19***	-0.36	-0.47	-0.51*	-0.50
Δ income source (cf. no change)									
Crops to other sources	-0.89**	-0.88**	-0.85*	-0.88**	-0.74**	0.37	-0.91**	-0.96**	-0.88**
Livestock to other sources	1.10**	1.11**	0.90	1.11**	1.68***	0.62	1.05*	0.67	1.11**
Other agriculture to other sources	-1.76**	-1.75**	-2.03**	-1.76**	-1.91**	-2.34***	-1.78**	-1.78**	-1.74**
Nonfarm activities to other sources	0.39	0.38	0.33	0.36	0.30	0.82*	0.37	0.31	0.40
Δ In distance to service									
Credit	-1.10*	-1.11*	-1.34**	-1.20*	-1.56**	-1.18**	-1.97	-1.25**	-1.00
All-weather road	-1.12***	-1.11***	-1.30***	-1.11***	-1.14***	-1.08***	-1.14***	-1.10***	-1.11***
Markets	0.15	0.15	0.07	0.15	0.19	0.19	0.17	0.14	0.18
In crop output_2004	-0.90***	-0.90***	-0.91***	-0.89***	-0.87***	-0.89***	-0.91***	-0.90***	-0.91***

NAADS × $\Delta$ gender of head		0.17							
NAADS × $\Delta$ ln age of head			-3.22 **						
NAADS × $\Delta$ education									
NAADS × reduction				0.00					
NAADS × improvement				0.60					
NAADS × $\Delta$ ln household size					1.57 **				
NAADS × $\Delta$ income source									
NAADS × crops to other sources						-1.46 ***			
NAADS × livestock to other sources						0.53			
NAADS × other agriculture to other sources						2.70 ***			
NAADS × nonfarm activities to other sources						-0.96			
NAADS × $\Delta$ ln distance to service									
NAADS × credit						0.93			
NAADS × all-weather road							-7.99		
NAADS × markets									-1.23 **
Intercept	10.71 ***	10.69 ***	10.74 ***	10.60 ***	10.37 ***	10.45 ***	10.73 ***	10.65 ***	10.73 ***
R-squared	0.46	0.46	0.50	0.46	0.48	0.48	0.46	0.56	0.46

Source: Matched sample of treatment and nontreatment households from NAADS-IFPRI 2004 and 2007 household survey panel data; based on Model III (see Table 5.7) and three nearest neighbor matches.

Notes: See Tables 5.1 and 5.2 for a detailed description of the variables. The treatment group in each case is  $NAADS_{DIR}$ . ln: transformation by natural logarithm;  $\Delta$ : change between 2004 and 2007 values. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Elsewhere, blank cells mean not applicable.

### **Livelihood Strategies and Land and Nonland Assets**

Direct participants in the program that experienced a shift in their primary sources of livelihood away from crop production activities were associated with a greater increase in agricultural revenue per AE, particularly when compared to those in areas where the program was never implemented. The amount of land owned was also a significant factor that enhanced the impacts of the program. Although the impact was greater among households that owned less than 1 acre of land, when  $NAADS_{DIR}$  households are compared with  $NAADS_{NON-3}$  households, it was lower when they are compared with  $NAADS_{NON-1}$  households. Among those where the program had never been implemented, the estimated impact on livestock productivity was greater among those that owned at least one acre of land. Looking at nonland assets (i.e., when the estimation is done for different asset terciles), we find that the NAADS program has been successful in increasing the average crop and livestock productivity and the agricultural revenue of the poor and the rich alike. For example, among the poorest households (tercile 1) and those in the middle-asset category (tercile 2), the estimated impacts were larger for livestock productivity and agricultural revenue, respectively. Together, these results suggest that the NAADS program's objective of targeting the economically active poor, including those with limited physical and financial assets, has been effective in increasing revenue. The fact that richer households, particularly those with greater land assets, also benefited underlies the importance of increasing households' capacity to acquire the improved technologies and related advisory services being promoted by the NAADS program.

### **Access to Services and Infrastructure and Regional Location**

The results associated with access to infrastructure are quite interesting, because they seem counterintuitive at first glance. Basically, the results from using the group approach show that the estimated average impact of the program was greater among households living relatively farther away from credit services and markets. This suggests that the NAADS program, by bringing farmers advisory services and grants for acquiring necessary technologies in addition to creating market linkages, has been more effective in areas with poor access to the services and infrastructure needed to support technology adoption and increased commercialization of agricultural production. Where access to such services and infrastructure (including access to all-weather roads) is good, farmers not participating in the program are able to acquire on their own the improved technologies being promoted by the NAADS program as well as related advisory services. Looking at the distribution of the impacts of the program across the four regions, the results are not statistically significant, with the exception of the result regarding greater average agricultural revenue

per AE in the subsample with  $NAADS_{NON-2}$  households in the Eastern Region. The Central and Western regions are the most developed regions in Uganda, and official national statistics show that households in the Central and Western regions have the highest and second-highest rural consumption expenditures, respectively (Uganda, BOS 2006). The Western and Central regions were also associated with the highest and third-highest growth rates in rural consumption expenditure, respectively (Uganda, BOS 2006).

## Conclusions

The primary purpose of this monograph is to assess the impacts of the NAADS program in Uganda. The program, which started in 2001 and has been planned to continue for 25 years, uses a public-private extension service delivery approach, with the goal of increasing market-oriented agricultural production by empowering farmers to demand and control agricultural advisory services. The assessment focuses on the period from 2004 to 2007, using panel data on 113 farmer groups and 719 households that were generated from two rounds of surveys conducted in 2004 and 2007. A combined matching and panel regression technique and different model specifications were used to evaluate the direct and indirect effects of the program on several outcome indicators, assess the distributive effects of the program and factors enhancing or mitigating these impacts, and analyze the sensitivity of the results. The outcomes evaluated include adoption of new crop and livestock enterprises and technologies, crop and livestock productivity, share of marketed agricultural outputs, agricultural income, and perception of change in food and nutrition security as well as overall wealth.

We find that direct participation in the program did not have any statistically significant effect on adoption of new crop and livestock enterprises or the improved agricultural technologies considered, except in the case of recommended planting and spacing practices, which were more widely adopted, but only when households directly participating in the NAADS program ( $NAADS_{DIR}$ ) were compared with those in areas where the program had never been implemented ( $NAADS_{NON-3}$ ). Direct participation had a greater average effect on livestock productivity than on crop productivity, which is consistent with the positive impact of the program on the sale of livestock and livestock products. The results related to change in agricultural revenue were mixed. Regarding the broader outcome indicators of food and nutrition security as well as overall wealth, we find that direct participation was generally positively associated with an improving situation and negatively associated with a worsening situation when direct participants are compared with both types of nonparticipants, either those based in the same areas where the program

was implemented ( $NAADS_{NON-2}$ ) or those based elsewhere ( $NAADS_{NON-3}$ ). The estimated indirect effects of the program, which were obtained based on comparison between the direct participants ( $NAADS_{DIR}$ ) and indirect participants ( $NAADS_{NON-1}$ ), were surprising: they were consistently negative for the different outcomes analyzed, suggesting that the impacts of the program on direct participants were not as great as the change observed among indirect participants. Because farmers in the group defined as indirect participants are not very familiar with the NAADS program, they may have confused NAADS service providers with agents of other programs, leading to an over-estimation of NAADS program effects for this group.

As expected, the impacts of the program were distributed differently across different groups of farmers in terms of gender, age, education, ownership of assets, and location. Furthermore, we find that different factors have contributed differently to enhancing or mitigating the effects of the program. The most striking result, one that is seemingly counterintuitive at first glance, is that the estimated average impact of the program was greater among households located relatively farther away from credit services and markets. This suggests that the NAADS program, by bringing farmers advisory services and grants for acquiring necessary technologies in addition to creating market linkages, has been more effective in areas with poor access to the services and infrastructure needed to support technology adoption and increased commercialization of agricultural production. Where access to such services and infrastructure is good (including in areas closer to all-weather roads), farmers are able to acquire on their own the improved technologies being promoted by the NAADS program as well as related advisory services.

In sum, the evidence, starting with the analysis of whether the NAADS program adequately induced participants to establish new enterprises or to adopt technologies and improved practices more frequently than their non-participating counterparts, seems patchy, with tenuous links, in terms of consistent sign and statistical significance across the different methods and model specifications, to increased productivity and commercialization of agriculture. Our underlying assumption is that participation in the NAADS program confers benefits via material inputs (seeds, livestock, fertilizers, etc.) that will lead to subsequent outcomes. But this assumption is not consistently validated in the results obtained. It is thus difficult to draw definitive conclusions regarding the direct impact of the NAADS program and, particularly, its indirect impact. This applies to our earlier results published in Benin et al. (2011).

Although we have tried to account for several important issues that are critical for a reliable program evaluation study, a major limitation here is our inability to capture in our estimations the separate effect of access to other or non-NAADS extension services. Basically, the government's regular exten-

sion service, as well as NGOs and others that provide agricultural advisory services through special projects, continued to operate in the same areas as the NAADS program and elsewhere. This is likely to cause overattribution of the estimated effects to the NAADS program, particularly where NAADS participants also benefited from other extension services, as was likely the result in Benin et al. (2011). Besides addressing this shortcoming, it will be useful for a follow-up to this study to look at the costs and benefits of investment in the program and assess the returns to such investment.

## Appendix: Second-Stage Regression Results

**Table A.1—Second-stage weighted regression results of change in the number of extension visits between 2004 and 2007**

Explanatory variables	NAADS <sub>NON-1</sub>			NAADS <sub>NON-2</sub>			NAADS <sub>NON-3</sub>		
	Model I	Model II	Model III	Model I	Model II	Model III	Model I	Model II	Model III
NAADS	-21.50 ***	-21.26 ***	-18.92 ***	2.61 ***	2.32 ***	2.20 ***	2.40 ***	1.01	1.09
Δ gender of head	6.45 *	8.53	22.93 *	-0.31	-0.39	-0.62	-0.53	-0.90	-0.32
Δ ln age of head	6.59	3.90	0.22	-2.71 *	-2.18	-3.60 **	-3.62 ***	-4.09 **	-4.09 **
Δ education (cf. no change)									
Reduction	-0.95	8.34	-6.86	2.52	2.38	2.39	7.96 *	8.10	8.03
Improvement	-13.48 **	-6.88	-2.16	-0.16	0.48	-0.16	0.93	0.81	-0.08
Δ ln household size	24.36 ***	27.27 ***	21.54 ***	0.11	0.20	-0.14	0.42	1.23 **	1.20 **
Δ income source (cf. no change)									
Crops to other sources	2.27	-4.85	-1.84	-0.71	0.24	0.12	-4.19 **	-2.33	-2.25
Livestock to other sources	-6.74 **	-19.43 ***	3.12	0.40	-0.26	-0.39	-2.48	-2.30	-2.34
Other agriculture to other sources	-6.73	3.52	7.29	-0.34	-1.21 **	-0.57	-5.24 **	-2.73 **	-5.53 ***
Nonfarm activities to other sources	-8.86 **	-2.62	-9.81 **	0.13	0.79	0.46	1.74	0.82	0.93
Δ ln distance to service									
Credit	7.69 ***	-1.92	12.58 ***	0.08	-0.01	-0.22	-0.85	-0.83	-1.07
All-weather road	-1.16	5.18 **	-4.36	-0.16	-0.15	-2.94 ***	-0.73	-0.94 *	-1.46
Markets	-7.40 ***	-6.92	-28.92	0.79	0.86	2.38 **	0.49	-0.35	2.38
ln extension_2004	-0.96 ***	-0.94 ***	-0.95 ***	-0.98 ***	-0.97 ***	-0.97 ***	-0.99 ***	-0.99 ***	-1.00 ***
Intercept	15.97 ***	12.45 ***	13.16 ***	0.96 *	0.75 *	1.23 ***	0.78	1.88 **	1.87 **
R-squared	1.00 ***	1.00 ***	1.00 ***	0.90 ***	0.92 ***	0.90 ***	0.81 ***	0.83 ***	0.83 ***

Source: Matched sample (based on three nearest neighbor matches) of treatment and nontreatment households from NAADS-IFPRI 2004 and 2007 household survey panel data.

Notes: See Tables 5.1 and 5.2 for a detailed description of the variables. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). The treatment group in each case is  $NAADS_{DIR}$ . ln: transformation by natural logarithm; Δ: change between 2004 and 2007 values. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance.

**Table A.2—Second-stage panel random-effects probit regression results of adoption of new crop and livestock enterprises in 2004 and 2007**

Explanatory variables	NAADS <sub>NON-1</sub>			NAADS <sub>NON-2</sub>			NAADS <sub>NON-3</sub>		
	Model I	Model II	Model III	Model I	Model II	Model III	Model I	Model II	Model III
New crop enterprises									
NAADS	-0.14	-0.08	-0.09	-0.24 *	-0.20	-0.19	0.28	0.07	0.09
Gender of head	0.25	0.13	0.46 **	0.18	0.22	0.24	0.36	0.36	0.30
In age of head	-0.39	-0.50 *	-0.63 *	-0.78 ***	-1.00 ***	-0.82 ***	-1.19 ***	-1.50 ***	-1.41 ***
Education (cf. no formal)									
Primary	-0.30	-0.55 **	-0.49 *	-0.22	-0.12	0.06	-0.35	-0.62 *	-0.57 *
Postprimary	0.02	-0.14	-0.12	0.04	0.34	0.43 *	0.37	0.05	0.14
In Household size	0.02	-0.01	0.33	-0.07	0.20	0.02	0.20	0.38 *	0.28
Membership in other organizations	0.22	0.31 *	0.09	0.27 **	0.14	0.22	-0.09	-0.02	-0.13
Income source (cf. crops)									
Livestock	0.55	0.48	0.42	0.39	0.63 *	0.17	1.06 **	0.95 *	0.95 *
Other agriculture	0.30	-0.35	0.29	0.39	0.58 **	0.34	0.58	0.47	0.49
Nonfarm activities	-0.08	-0.17	-0.13	-0.03	-0.06	0.05	-0.38	-0.40	-0.29
In distance to service									
Credit	-0.02	-0.03	0.05	-0.11	0.07	0.05	0.03	0.09	0.10
All-weather road	-0.01	-0.08	-0.02	-0.07	-0.03	-0.04	-0.12	-0.06	-0.06
Markets	0.02	-0.01	-0.15	0.04	-0.06	-0.08	-0.15	-0.24	-0.23
Region (cf. Central)									
Eastern	-0.60 **	-0.40	-0.29	-0.58 ***	-0.70 ***	-0.41 *	-1.53 ***	-1.51 ***	-1.41 ***
Northern	-0.24	-0.43	0.15	-0.52 **	-0.72 ***	-0.47 *			
Western	-0.29	-0.29	0.09	-0.22	-0.30	-0.05	-1.08 ***	-1.20 ***	-1.14 ***
Intercept	1.41	2.09 *	1.76	3.21 ***	3.33 ***	2.61 ***	4.84 ***	6.15 ***	5.85 ***
Chi-squared	19.93	26.25	17.43	38.88	44.50	34.80	52.68	48.22	46.81

(continued)

Table A.2—Continued

Explanatory variables	NAADS <sub>NON-1</sub>			NAADS <sub>NON-2</sub>			NAADS <sub>NON-3</sub>		
	Model I	Model II	Model III	Model I	Model II	Model III	Model I	Model II	Model III
New livestock enterprises									
NAADS	-0.15	-0.04	-0.14	-0.23	-0.27	-0.14	-0.05	0.01	0.10
Gender of head	-0.01	0.05	0.06	0.17	-0.03	-0.08	0.89***	0.80***	0.81***
In age of head	-0.46	-0.72**	-0.49	-0.55*	-0.25	-0.45	-0.80**	-0.66*	-0.91**
Education (cf. no formal)									
Primary	-0.38	-0.46	-0.49	0.10	-0.15	-0.21	-0.14	-0.44	-0.42
Postprimary	0.00	-0.13	-0.21	0.64**	0.25	0.19	0.29	0.29	0.29
In household size	0.15	0.22	0.24	0.15	-0.11	0.07	0.16	0.27	0.15
Membership in other organizations	-0.18	-0.08	-0.12	0.07	0.24	0.23	-0.06	-0.04	-0.12
Income source (cf. crops)									
Livestock	0.52	0.50	-0.35	-0.05	0.11	-0.21	0.50	0.46	0.46
Other agriculture	0.62	0.57	0.70	-0.12	0.12	-0.39	0.61	-0.17	-0.28
Nonfarm activities	0.12	0.21	0.11	-0.20	-0.15	-0.29	0.37	0.11	0.31
In distance to service									
Credit	0.11	0.07	0.00	-0.02	0.08	-0.03	0.02	0.03	0.01
All-weather road	-0.10	-0.07	0.02	-0.03	-0.05	-0.01	0.00	0.01	-0.04
Markets	-0.09	0.00	0.02	-0.06	-0.27*	0.00	-0.07	-0.28	-0.35
Region (cf. Central)									
Eastern	0.26	0.20	0.09	0.17	0.19	0.50*	0.21	0.48	0.47
Northern	-0.58*	-0.65*	-0.62*	-0.37	-0.41	0.08			
Western	-0.40	-0.39	-0.42	0.04	0.16	0.23	0.00	0.20	0.24
Intercept	0.85	1.64	1.12	0.72	0.28	0.35	1.20	0.86	2.05
Chi-squared	23.66	22.03	16.85	13.79	20.32	11.70	18.26	21.17	21.15

Source: Matched sample (based on three nearest neighbor matches) of treatment and nontreatment households from NAADS-IFPRI 2004 and 2007 household survey panel data.

Notes: See Tables 5.1 and 5.2 for a detailed description of the variables. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). The treatment group in each case is  $NAADS_{DIR}$ . In: transformation by natural logarithm. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Elsewhere, blank cells mean not estimated due to limited sample observations across categories of the dependent variable.

**Table A.3—Second-stage panel random-effects probit regression results of adoption of improved crop and livestock technologies and practices in 2004 and 2007**

Explanatory variables	NAADS <sub>NON-1</sub>			NAADS <sub>NON-2</sub>			NAADS <sub>NON-3</sub>		
	Model I	Model II	Model III	Model I	Model II	Model III	Model I	Model II	Model III
Improved crop varieties									
NAADS	0.10	-0.25	-0.19	0.15	0.12	0.24	0.25	0.23	0.31 *
Gender of head	0.15	-0.07	0.25	0.43 **	0.09	0.17	0.21	0.37	0.33
In age of head	-0.28	0.07	-0.30	0.01	-0.09	-0.06	-0.20	-0.16	-0.03
Education (cf. no formal)									
Primary	0.06	0.07	-0.02	0.25	0.01	0.13	0.08	0.20	0.19
Postprimary	0.05	0.03	0.14	0.52 **	-0.05	0.19	0.52 *	0.64 **	0.75 **
In household size	0.54 ***	0.33 *	0.53 ***	0.43 ***	0.40 ***	0.35 **	0.33 *	0.34 *	0.38 **
Membership in other organizations	0.58 ***	0.72 ***	0.45 ***	0.26 *	0.26 *	0.33 **	0.25	0.26	0.26
Income source (cf. crops)									
Livestock	-0.54	-0.70 *	-0.62	-0.47	-0.22	-0.40	-0.35	-0.20	-0.33
Other agriculture	0.57	0.33	0.17	-0.37	-0.14	-0.39	-0.45	-0.57	-0.82
Nonfarm activities	0.43 *	0.57 **	0.61 ***	0.54 ***	0.51 ***	0.42 **	0.23	0.38	0.27
In distance to service									
Credit	-0.02	-0.09	-0.09	0.05	0.08	0.02	0.05	0.07	0.05
All-weather road	-0.17 **	-0.04	-0.06	-0.11 **	-0.09	-0.06	-0.05	-0.07	-0.12
Markets	-0.03	0.11	0.10	0.02	0.05	0.06	0.06	0.01	0.07
Region (cf. Central)									
Eastern	0.06	0.44	0.22	-0.04	-0.12	-0.20	-0.25	-0.10	-0.06
Northern	-0.12	0.42	0.22	-0.23	-0.26	-0.54 **			
Western	-1.02 ***	-0.60 **	-0.86 ***	-1.03 ***	-1.17 ***	-1.27 ***	-1.08 ***	-0.95 ***	-0.88 ***
Intercept	0.24	-0.97	0.44	-1.05	-0.35	-0.41	0.01	-0.42	-1.08
Chi-squared	60.10	62.58	69.23	77.36	72.85	69.00	39.59	41.73	43.53

(continued)

Table A.3—Continued

Explanatory variables	NAADS <sub>NON-1</sub>			NAADS <sub>NON-2</sub>			NAADS <sub>NON-3</sub>		
	Model I	Model II	Model III	Model I	Model II	Model III	Model I	Model II	Model III
Recommended planting and spacing practices									
NAADS	-0.33**	-0.48***	-0.42**	0.04	0.01	-0.13	0.22	0.39**	0.35*
Gender of head	0.25	0.34	0.26	0.12	0.23	0.28	-0.22	0.04	0.00
In age of head	-0.26	0.00	-0.10	0.01	0.02	-0.03	-0.06	0.02	0.00
Education (cf. no formal)									
Primary	0.55**	0.28	0.66**	0.37	0.46**	0.42*	0.49*	0.62**	0.58**
Postprimary	0.49	0.79**	0.74**	0.79***	0.76***	0.70***	0.62*	0.62*	0.58*
In household size	-0.14	-0.14	-0.14	0.15	0.08	0.11	0.04	0.09	0.11
Membership in other organizations	0.54***	0.52***	0.51***	0.34**	0.43***	0.28**	0.39**	0.43**	0.41**
Income source (cf. crops)									
Livestock	-0.20	-0.58	-0.46	-0.37	0.30	-0.01	0.65	0.48	0.48
Other agriculture	-0.55	-0.42	-0.46	-0.39	-0.56*	-0.53*	-1.54**	-0.63	-0.86*
Nonfarm activities	0.24	0.34	0.13	-0.08	-0.06	-0.06	0.06	0.22	0.11
In distance to service									
Credit	0.02	0.01	-0.06	-0.07	-0.05	0.00	0.07	-0.03	0.02
All-weather road	0.07	0.09	0.05	-0.01	0.06	0.02	0.00	-0.03	-0.04
Markets	0.13	0.08	0.26**	-0.03	-0.16	-0.15	0.11	0.31*	0.31**
Region (cf. Central)									
Eastern	-0.60**	-0.99***	-0.69**	-0.56**	-0.28	-0.45**	-0.75***	-0.46*	-0.59**
Northern	-0.10	-0.19	-0.09	0.48*	0.72***	0.35			
Western	-1.00***	-1.30***	-1.06***	-0.85***	-0.69***	-0.81***	-1.34***	-1.00***	-1.11***
Intercept	0.87	0.52	0.27	-0.33	-0.38	0.02	-0.21	-1.36	-1.22
Chi-squared	47.76	54.52	37.59	70.49	72.73	64.45	40.04	36.50	40.16
Inorganic fertilizers									
NAADS	0.02	-0.04	-0.22	0.27	0.28	0.06		0.11	0.25
Gender of head	-0.09	-0.02	-0.07	0.27	0.58*	0.49*		-0.21	-0.29
In age of head	0.03	0.06	0.50	0.03	-0.23	-0.37		0.48	0.42
Education (cf. no formal)									
Primary	0.68	0.61	0.36	0.44	0.07	0.12		6.15	6.26
Postprimary	0.04	0.39	-0.52	0.42	-0.29	-0.10		5.62	5.96
In household size	-0.24	-0.59**	-0.13	0.18	0.55**	0.45*		0.02	-0.06

Membership in other organizations	-0.14	-0.14	-0.46	-0.25	-0.25	-0.17		0.11	0.15
Income source (cf. crops)									
Livestock	0.40	0.44	-0.03	0.65	0.67	0.82*		1.39**	1.40**
Other agriculture	0.54	0.20	0.31	0.19	-6.03	-0.23		-6.68	-6.87
Nonfarm activities	0.47	0.63**	0.10	-0.06	-0.09	0.00		-0.10	-0.25
In distance to service									
Credit	0.01	-0.12	-0.05	-0.23*	-0.03	-0.07		0.09	0.08
All-weather road	0.17*	0.08	0.26**	0.05	0.06	-0.07		0.10	0.16
Markets	0.19	0.19	0.33	-0.17	-0.43**	-0.30*		-0.12	-0.17
Region (cf. Central)									
Eastern	-0.63	-0.81*	-0.99**	-0.51	-0.70	-0.38		-1.77***	-1.65***
Northern	-0.40	-0.82*	-1.10**	0.26	0.36	0.18			
Western	-0.62*	-0.93**	-1.23***	-0.46	-0.48	-0.42		-1.34**	-1.30**
Intercept	-1.64	-0.70	-2.62	-1.34	-0.70	-0.01		-8.33	-8.24
Chi-squared	11.55	14.09	13.29	18.18	16.82	17.74		13.23	11.75
Pesticides									
NAADS	-0.19	-0.13	-0.24	0.14	0.10	-0.11	-0.15	-0.07	-0.01
Gender of head	-0.49**	-0.28	-0.32	-0.29	-0.21	-0.23	-0.20	-0.51*	-0.54*
In age of head	-0.58**	-0.38	-0.20	-0.19	-0.72**	-0.46	-0.64**	-0.33	-0.44
Education (cf. no formal)									
Primary	-0.15	0.05	0.07	0.28	0.34	0.39	0.08	-0.19	0.00
Postprimary	0.34	0.39	0.34	0.63*	0.66**	0.62*	0.63*	0.38	0.60
In household size	0.03	0.03	-0.11	0.15	0.44**	0.21	0.16	0.12	0.19
Membership in other organizations	0.53***	0.58***	0.65***	0.24	0.30*	0.24	0.29	0.45**	0.32
Income source (cf. crops)									
Livestock	-0.10	-0.03	-0.38	0.36	0.33	-0.12	0.60	0.64	0.64
Other agriculture	-0.41	-0.70	-0.27	-0.60	-0.22	-0.30	-0.66	-0.73	-0.74
Nonfarm activities	-0.15	-0.24	0.01	-0.07	-0.24	-0.15	-0.41	-0.26	-0.27
In distance to service									
Credit	-0.09	-0.06	-0.18**	-0.17	-0.07	-0.16	-0.06	0.00	0.01
All-weather road	0.08	0.05	0.04	-0.02	0.11	0.10	0.04	0.03	-0.02
Markets	0.02	0.02	0.12	-0.07	-0.12	-0.13	0.11	0.00	-0.09
Region (cf. Central)									
Eastern	0.28	0.18	0.36	0.40	0.54**	0.42	-0.47*	-0.23	-0.34
Northern	-0.52*	-0.39	-0.30	-0.39	-0.09	-0.14			
Western	-0.32	-0.27	-0.15	-0.18	-0.01	0.11	-0.76**	-0.51	-0.53*
Intercept	1.61	0.50	0.08	-0.35	0.79	0.62	1.65	0.50	0.83
Chi-squared	43.87	29.13	34.53	22.01	41.19	22.56	28.89	25.64	26.04

(continued)

Table A.3—Continued

Explanatory variables	NAADS <sub>NON-1</sub>			NAADS <sub>NON-2</sub>			NAADS <sub>NON-3</sub>		
	Model I	Model II	Model III	Model I	Model II	Model III	Model I	Model II	Model III
Improved livestock breeds									
NAADS	-0.08	-0.08	-0.13	0.04	0.08	0.19	0.08	0.13	0.19
Gender of head	-0.41 *	-0.38	-0.36	0.16	0.03	-0.01	0.08	0.02	0.05
In age of head	0.41	0.27	0.26	0.46	0.39	0.22	0.58	0.51	0.63
Education (cf. no formal)									
Primary	0.44	0.52	0.49	0.30	0.10	0.32	1.02*	1.01 *	0.94 *
Postprimary	0.74**	1.07***	0.59	0.45	0.23	0.40	1.07*	0.93	1.05 *
In household size	0.11	-0.02	-0.09	0.28 *	0.35*	0.25	0.30	0.30	0.29
Membership in other organizations	0.52**	0.28	0.26	0.08	0.28	0.21	0.56**	0.62 **	0.54 **
Income source (cf. crops)									
Livestock	0.37	0.94***	0.89**	0.34	0.12	0.19	1.00**	1.05 **	0.97 **
Other agriculture	0.13	0.03	0.15	-0.22	0.23	-0.01	-0.22	-0.13	-0.40
Nonfarm activities	0.30	0.08	0.28	0.32 *	0.29	0.42**	0.38	0.34	0.24
In distance to service									
Credit	-0.07	-0.10	-0.02	0.04	0.04	0.06	-0.10	-0.04	-0.07
All-weather road	-0.21***	-0.17**	-0.16*	0.07	0.03	0.04	0.00	-0.05	-0.06
Markets	-0.16	0.01	-0.05	-0.05	-0.07	-0.35**	-0.03	-0.11	-0.11
Region (cf. Central)									
Eastern	-0.17	-0.57 *	-0.30	-0.51 **	-0.79***	-0.44	-0.83***	-0.90 ***	-0.65 **
Northern	-0.51 *	-1.33***	-1.11***	-0.92***	-0.82**	-0.63*			
Western	-0.28	-0.81***	-0.42	-0.48 **	-0.65**	-0.15	-0.32	-0.25	-0.10
Intercept	-2.69**	-1.70	-1.77	-3.12***	-2.80**	-2.25	-4.34**	-4.14 **	-4.56***
Chi-squared	37.12	41.46	20.35	27.52	24.35	23.64	39.08	35.72	31.77

Source: Matched sample (based on three nearest neighbor matches) of treatment and nontreatment households from NAADS-IFPRI 2004 and 2007 household survey panel data.

Notes: See Tables 5.1 and 5.2 for a detailed description of the variables. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). The treatment group in each case is  $NAADS_{DIR}$ . In: transformation by natural logarithm. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Elsewhere, blank cells mean not estimated because of lack of observations.

**Table A.4—Second-stage weighted regression results of change in the logarithm of the value of total crop output per acre between 2004 and 2007**

Explanatory variables	NAADS <sub>NON-1</sub>			NAADS <sub>NON-2</sub>			NAADS <sub>NON-3</sub>		
	Model I	Model II	Model III	Model I	Model II	Model III	Model I	Model II	Model III
NAADS	-0.25	-0.38	-0.59**	-0.01	0.30	0.09	0.73	0.62	0.88*
Δ gender of head	-0.62	0.13	-0.76	-0.60	-0.56	-0.99	-0.10	-0.52	-0.29
Δ ln age of head	-0.75	-0.08	-1.94***	-0.67	-1.01	-0.93*	-2.31**	-2.19*	-2.58*
Δ education (cf. no change)									
Reduction	-0.61	0.61	-1.22***	-0.54	-0.50	0.01	-2.13	-2.66*	-2.48*
Improvement	0.13	-1.07***	-0.47	-0.22	-1.60	-0.83	-0.04	-0.18	-0.47
Δ ln household size	0.23	0.33	-0.11	0.26	0.21	0.16	1.19**	1.42**	1.36**
Δ income source (cf. no change)									
Crops to other sources	0.87	-0.68**	-0.29	0.59*	0.89**	0.10	1.04	1.26	1.33*
Livestock to other sources	0.08	1.17	0.15	-0.78	0.69**	-1.13	1.50	1.71	1.83
Other agriculture to other sources	0.63	0.82*	0.03	0.20	0.23	0.77	-0.77	-0.92	-0.69
Nonfarm activities to other sources	-0.12	0.24	0.00	0.14	0.39	-0.03	0.03	0.73	0.57
Δ ln distance to service									
Credit	-0.60**	-0.27	0.12	0.16	0.45	-0.08	-0.82	-0.22	-0.25
All-weather road	0.13	0.69	-0.14	-0.58	-0.47	0.28	1.37**	1.75*	1.84**
Markets	-0.34	-0.70	-0.23	-0.19	0.40	-0.90	0.00	1.18	0.21
ln crop output_2004	-0.90***	-0.74***	-0.92***	-0.69***	-0.58***	-0.73***	-0.93***	-0.64***	-0.66***
Intercept	10.80***	8.89***	11.66***	8.17***	6.63***	8.59***	10.09***	6.72***	6.74***
R-squared	0.72***	0.74***	0.84***	0.44***	0.27***	0.35***	0.55***	0.51***	0.53***

Source: Matched sample (based on three nearest neighbor matches) of treatment and nontreatment households from NAADS-IFPRI 2004 and 2007 household survey panel data.

Notes: See Tables 5.1 and 5.2 for a detailed description of the variables. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). The treatment group in each case is  $NAADS_{DIR}$ . ln: transformation by natural logarithm; Δ: change between 2004 and 2007 values. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance.

**Table A.5—Second-stage weighted regression results of change in the logarithm of the value of total livestock output per tropical livestock unit between 2004 and 2007**

Explanatory variables	NAADS <sub>NON-1</sub>			NAADS <sub>NON-2</sub>			NAADS <sub>NON-3</sub>		
	Model I	Model II	Model III	Model I	Model II	Model III	Model I	Model II	Model III
NAADS	0.04	-0.09	-0.49	0.66	0.00	0.29	0.44	1.20**	0.98**
Δ gender of head	-0.69*	-0.59	-0.49	0.27	-0.75***	-0.23	0.20	-0.45	-0.18
Δ ln age of head	-0.58	0.58	-0.27	-0.70	0.21	-0.47	-0.16	0.45	-0.31
Δ education (cf. no change)									
Reduction	-0.34	-0.19	-0.04	0.48	-0.03	-0.08	0.52	1.27***	1.05**
Improvement	-1.20**	-0.51	-1.04**	0.54	-0.96	-1.18*	-0.92	0.27	-0.65
Δ ln household size	0.78*	0.43	0.13	0.68	1.06***	0.75***	0.35	0.97**	0.95**
Δ income source (cf. no change)									
Crops to other sources	-0.57	0.08	0.57	0.24	0.12	0.61	-0.24	-0.75	-0.41
Livestock to other sources	2.70***	-0.45	0.45	-0.55	1.00	-0.68***	-0.59*	0.45	0.23
Other agriculture to other sources	1.15	0.08	0.11	-0.43	-1.36*	-0.18	0.26	-0.38	-0.38
Nonfarm activities to other sources	-0.07	0.33	0.25	-0.47	-0.72**	-0.32	0.22	-0.68	-0.68
Δ ln distance to service									
Credit	0.09	0.24	0.28	-0.61*	-0.57*	-0.43	-0.23	-1.06	-1.24
All-weather road	0.58	0.28	0.15	-1.01	-4.93	-6.26	-1.48	-20.57**	-11.42
Markets	0.95	-0.05	0.76	-5.83**	-3.16***	-5.16**	0.96	-2.35	-0.44
ln livestock output_2004	-0.57***	-0.81***	-0.65***	-0.38***	-0.35***	-0.41***	-0.53***	-0.67***	-0.58***
Intercept	7.56***	10.44***	9.02***	5.03***	5.53***	5.70***	7.11***	7.79***	7.05***
R-squared	0.36**	0.48***	0.43***	0.30***	0.40***	0.36***	0.39***	0.51***	0.46***

Source: Matched sample (based on three nearest neighbor matches) of treatment and nontreatment households from NAADS-IFPRI 2004 and 2007 household survey panel data.

Notes: See Tables 5.1 and 5.2 for a detailed description of the variables. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). The treatment group in each case is  $NAADS_{DIR}$ . ln: transformation by natural logarithm; Δ: change between 2004 and 2007 values. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance.

**Table A.6—Second-stage weighted regression results of change in the percentage of the total value of crop output that was sold between 2004 and 2007**

Explanatory variables	NAADS <sub>NON-1</sub>			NAADS <sub>NON-2</sub>			NAADS <sub>NON-3</sub>		
	Model I	Model II	Model III	Model I	Model II	Model III	Model I	Model II	Model III
NAADS	-1.18	-1.12	-1.11	0.67	-1.21	1.01	2.85	0.72	5.06
Δ gender of head	4.40	-4.10	0.61	-4.77	0.30	-5.37	-6.40	-7.08	-13.00*
Δ ln age of head	-24.07**	-36.36***	-15.81	-23.00***	-16.93**	-12.31	-14.10	-18.42*	-15.38
Δ education (cf. no change)									
Reduction	-6.74	6.06	8.36	-4.43	-11.15*	1.38	9.27	10.91	8.72
Improvement	-10.67*	-9.26	-7.07	-11.54	-12.32**	-9.73*	-0.58	-1.48	-3.14
Δ ln household size	-6.59	-13.80*	-16.26**	-0.19	2.73	5.38	-1.97	1.10	0.51
Δ income source (cf. no change)									
Crops to other sources	11.86	2.24	-17.76***	13.58	-9.93	-3.64	8.49	9.05	5.51
Livestock to other sources	-3.95	4.04	-9.08	9.48	-8.57	-8.74	23.56	31.70*	17.56
Other agriculture to other sources	17.50	9.67	9.41	-19.85***	23.95	-1.06	-13.32**	-17.97**	-17.57**
Nonfarm activities to other sources	-1.72	3.62	-1.90	0.19	-6.02	-0.21	9.85	7.56	6.33
Δ ln distance to service									
Credit	-3.23	-9.08	15.19***	19.99***	14.25**	13.92***	14.62	15.19	18.91
All-weather road	-27.21**	1.20	-16.69***	-6.16***	-189.13	-3.59	-17.05***	-14.79***	-17.48***
Markets	2.26	0.30	-3.29	-17.22	-14.30	-18.80	-0.51	-1.45	-1.26
ln crop market_2004	-0.72***	-0.67***	-0.82***	-0.85***	-0.70***	-0.76***	-0.74***	-0.88***	-0.87***
Intercept	23.36***	21.45***	30.32***	25.88***	25.20***	22.13***	13.94**	20.91***	19.30***
R-squared	0.44***	0.45***	0.49***	0.46***	0.40***	0.43***	0.49***	0.56***	0.54***

Source: Matched sample (based on three nearest neighbor matches) of treatment and nontreatment households from NAADS-IFPRI 2004 and 2007 household survey panel data.

Notes: See Tables 5.1 and 5.2 for a detailed description of the variables. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). The treatment group in each case is  $NAADS_{DIR}$ . ln: transformation by natural logarithm; Δ: change between 2004 and 2007 values. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance.

**Table A.7—Second-stage weighted regression results of change in the percentage of the total value of livestock output that was sold between 2004 and 2007**

Explanatory variables	NAADS <sub>NON-1</sub>			NAADS <sub>NON-2</sub>			NAADS <sub>NON-3</sub>		
	Model I	Model II	Model III	Model I	Model II	Model III	Model I	Model II	Model III
NAADS	7.12*	-2.34	-0.09	7.62***	5.19**	3.61	-0.57	7.39**	7.82***
Δ gender of head	1.64	9.98	3.55	9.82	14.57**	15.72**	10.41	14.32**	10.71*
Δ ln age of head	14.84*	17.35**	20.54**	6.90	6.05	10.22*	16.77	10.22**	11.96***
Δ education (cf. no change)									
Reduction	3.46	12.78*	14.63***	15.61**	9.21*	12.26*	24.69*	19.14**	15.88**
Improvement	4.90	5.16	7.34	13.00**	11.86**	12.62**	6.28	6.14	8.31*
Δ ln household size	5.83**	4.53	6.46*	-0.95	1.14	4.07	-7.64	-6.60***	-3.80**
Δ income source (cf. no change)									
Crops to other sources	-1.50	-5.05	-8.76**	-4.29	-5.95	0.03	-9.26	-12.77**	-11.05*
Livestock to other sources	11.14	42.37*	-7.82	36.17***	45.98***	53.10***	25.22	34.37*	42.22*
Other agriculture to other sources	23.73**	11.77	21.32*	12.00	17.93*	3.66	-1.41	1.00	1.87
Nonfarm activities to other sources	6.08**	6.27	7.49*	0.90	3.13	0.98	26.04**	10.79***	8.68***
Δ ln distance to service									
Credit	1.30	8.53	4.89*	3.09	6.29	0.82	18.67**	11.12***	9.65**
All-weather road	-12.98***	-11.90**	-10.30**	-7.30	-10.77	-1.61	-6.20	-2.10	-1.66
Markets	8.92	-1.34	-7.21	5.48*	8.69**	6.33*	3.73	5.99*	0.05
ln livestock market_2004	-1.01***	-1.02***	-1.02***	-1.01***	-0.98***	-0.95***	-1.05***	-1.00***	-1.00***
Intercept	-2.44	4.81	2.44	-1.36	0.04	-0.08	2.76	-1.40	-2.03
R-squared	0.89***	0.88***	0.86***	0.86***	0.90***	0.88***	0.78***	0.92***	0.93***

Source of data: Matched sample (based on three nearest neighbor matches) of treatment and nontreatment households from NAADS-IFPRI 2004 and 2007 household survey panel data.

Notes: See Tables 5.1 and 5.2 for a detailed description of the variables. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). The treatment group in each case is  $NAADS_{DIR}$ . ln: transformation by natural logarithm; Δ: change between 2004 and 2007 values. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance.

**Table A.8—Second-stage weighted regression results of change in the percentage of the total value of agricultural output that was sold between 2004 and 2007**

Explanatory variables	NAADS <sub>NON-1</sub>			NAADS <sub>NON-2</sub>			NAADS <sub>NON-3</sub>		
	Model I	Model II	Model III	Model I	Model II	Model III	Model I	Model II	Model III
NAADS	2.34	-5.86	-6.13	1.92	0.45	0.38	6.18*	0.02	2.14
Δ gender of head	8.78	1.26	8.02	5.08	2.61	3.71	3.36	2.87	4.45
Δ ln age of head	7.55	-8.44	8.01	-2.88	-12.17***	-6.43	-9.43*	-13.68**	-16.34**
Δ education (cf. no change)									
Reduction	-4.99	19.97*	2.06	0.79	2.77	-2.88	11.06	1.20	2.61
Improvement	-4.03	6.83	5.60	-3.32	-0.16	-4.73	1.15	5.32	10.64*
Δ ln household size	2.31	-14.16**	-0.16	-2.37	-2.03	4.46	-1.20	-3.31	-4.66
Δ income source (cf. no change)									
Crops to other sources	5.39	0.39	-4.69	-8.96***	-3.42	-6.06	-9.68	5.80	7.25
Livestock to other sources	5.76	-23.82	-11.17	11.19	-7.77	-8.63	29.12**	26.18	27.59
Other agriculture to other sources	6.88	-23.78***	-20.08***	-5.09	16.27	-0.40	-12.40***	-13.44***	-11.87***
Nonfarm activities to other sources	-2.83	-4.61	-12.07**	2.00	-2.54	-2.69	4.88	8.99*	5.87
Δ ln distance to service									
Credit	-4.54*	-2.35	7.28*	6.64	11.07***	10.41***	15.01**	8.01	6.95
All-weather road	-6.67*	1.90	-9.07*	-2.28	-26.27***	-88.66	-11.26*	-14.79**	-13.91*
Markets	0.35	-24.38	-2.13	-15.81**	-10.20	-10.84	0.47	-10.25***	-8.72**
ln agriculture market_2004	-0.81***	-0.95***	-0.91***	-0.90***	-0.90***	-0.95***	-1.00***	-0.89***	-0.90***
Intercept	8.51**	22.95***	23.06***	15.03***	18.48***	19.88***	12.21***	12.59***	10.71**
R-squared	0.58***	0.59***	0.56***	0.64***	0.64***	0.66***	0.77***	0.65***	0.68***

Source: Matched sample (based on three nearest neighbor matches) of treatment and nontreatment households from NAADS-IFPRI 2004 and 2007 household survey panel data.

Notes: See Tables 5.1 and 5.2 for a detailed description of the variables. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). The treatment group in each case is  $NAADS_{DIR}$ . ln: transformation by natural logarithm; Δ: change between 2004 and 2007 values. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance.

**Table A.9—Second-stage weighted regression results of change in the logarithm of agricultural revenue per adult equivalent between 2004 and 2007**

Explanatory variables	NAADS <sub>NON-1</sub>			NAADS <sub>NON-2</sub>			NAADS <sub>NON-3</sub>		
	Model I	Model II	Model III	Model I	Model II	Model III	Model I	Model II	Model III
NAADS	0.09	-0.27	-0.08	0.67***	0.27	0.43**	0.16	0.23	0.27
Δ gender of head	0.32	0.12	-0.07	0.64*	0.86**	0.46	0.48	-0.02	0.56
Δ ln age of head	-0.18	0.53	-0.09	-0.04	0.33	0.26	-0.03	0.09	-0.24
Δ education (cf. no change)									
Reduction	0.34	-0.02	-0.50	-0.22	-0.56*	-0.26	1.18*	0.11	0.37
Improvement	0.06	-0.33	-0.14	-0.13	-0.18	-0.31	-0.25	0.15	-0.33
Δ ln household size	-0.30	0.16	0.12	0.23	0.02	-0.04	-0.07	-0.45	-0.49
Δ income source (cf. no change)									
Crops to other sources	-0.15	0.08	-0.30	-0.38	-1.15***	-0.41	-1.25***	-0.80	-0.89**
Livestock to other sources	0.73	1.37*	0.53	0.85**	0.79	1.25**	0.79	1.05**	1.10**
Other agriculture to other sources	0.46	1.34	-0.37	0.71**	0.46	0.16	-2.10***	-2.00**	-1.76**
Nonfarm activities to other sources	0.03	0.19	-0.12	-0.17	-0.37	-0.31	0.10	0.47	0.39
Δ ln distance to service									
Credit	0.41*	-0.71	0.05	-0.59***	-0.29	-0.40**	-1.38**	-0.09	-1.10*
All-weather road	-0.51*	1.08	0.47**	0.88***	0.30	0.81***	-1.43***	-0.74	-1.12***
Markets	-0.05	1.40	0.23	0.09	-0.48	-0.90*	-0.12	-1.26***	0.15
ln agricultural output_2004	-0.75***	-0.83***	-0.68***	-0.67***	-0.69***	-0.83***	-1.05***	-0.97***	-0.90***
Intercept	9.09***	10.26***	8.45***	7.69***	8.62***	9.92***	12.47***	11.67***	10.71***
R-squared	0.41***	0.43***	0.34***	0.43***	0.42***	0.49***	0.49***	0.43***	0.46***

Source: Matched sample (based on three nearest neighbor matches) of treatment and nontreatment households from NAADS-IFPRI 2004 and 2007 household survey panel data.

Notes: See Tables 5.1 and 5.2 for a detailed description of the variables. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). The treatment group in each case is  $NAADS_{DIR}$ . ln: transformation by natural logarithm; Δ: change between 2004 and 2007 values. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance.

**Table A.10—Second-stage multinomial-probit regression results of perception of change in access to adequate food between 2004 and 2007**

Explanatory variables	NAADS <sub>NON-1</sub>			NAADS <sub>NON-2</sub>			NAADS <sub>NON-3</sub>		
	Model I	Model II	Model III	Model I	Model II	Model III	Model I	Model II	Model III
Worsened (cf. no change)									
NAADS	-0.82*	-0.78	-0.56	-0.78*	-0.01	-0.46	-0.30	-0.22	-0.13
Δ gender of head	1.35	1.40	-0.07	0.38	0.07	0.77	1.92**	1.71**	1.62*
Δ ln age of head	4.53*	-0.03	0.01	-0.15	-0.99	-0.98	-1.35	-0.92	-0.89
Δ education (cf. no change)									
Reduction	-0.01	-0.33	0.17	0.26	-0.15	-0.23	-0.04	0.09	0.14
Improvement	-2.56**	-2.71***	-0.04	0.05	0.74	-0.16	0.01	0.47	0.61
Δ ln household size	0.95	0.82	-0.52	0.51	0.28	0.49	0.87**	0.92**	0.89**
Δ income source (cf. no change)									
Crops to other sources	0.39	0.84	-1.22*	0.15	-1.08*	-0.68	-2.80***	-2.84**	-2.89***
Livestock to other sources	-13.87***	-11.72***	-11.46***	-1.25	0.15	0.18	1.00	1.74	2.02
Other agriculture to other sources	0.22	-1.31	-1.23	-1.41*	-0.24	-1.97**	-1.25	-0.89	-0.76
Nonfarm activities to other sources	-0.72	-1.49**	-0.18	0.23	0.26	0.00	-0.09	-0.23	-0.21
Δ ln distance to service									
Credit	0.09	0.27	0.43	-0.33	-0.65**	-0.50	-2.81**	-3.29**	-3.23**
All-weather road	-0.23	-0.91*	-0.20	3.14	-0.64	-0.60	28.67**	34.51***	40.37***
Markets	-1.52*	-0.30	1.09	-1.23	1.38	-0.39	0.56**	0.72***	0.95***
Perception in 2000-04									
Improved	-1.45**	-1.43**	-0.41	-0.49	-0.38	-0.38	0.48	0.65	0.59
Worsened									
Intercept	1.28**	1.78***	0.83	0.71*	0.02	0.54	0.33	0.00	-0.02

(continued)

Table A.10—Continued

Explanatory variables	NAADS <sub>NON-1</sub>			NAADS <sub>NON-2</sub>			NAADS <sub>NON-3</sub>		
	Model I	Model II	Model III	Model I	Model II	Model III	Model I	Model II	Model III
Improved (cf. no change)									
NAADS	-0.34	-0.62	-0.24	0.11	0.83**	0.44	0.83*	0.75	0.90*
Δ gender of head	0.50	2.29***	0.02	0.20	-0.22	0.32	0.43	0.55	0.40
Δ ln age of head	0.63	-0.71	-0.25	-0.67	-1.04	-0.96	-0.29	0.15	0.06
Δ education (cf. no change)									
Reduction	-0.37	-0.11	-0.43	-0.16	-0.40	-0.78	-1.09	-1.78**	-1.74**
Improvement	0.36	0.17	-0.15	0.44	1.05	0.30	1.11*	1.06*	1.28*
Δ ln household size	0.82	0.42	-0.06	1.13***	0.46	0.72*	0.83**	0.77*	0.85**
Δ income source (cf. no change)									
Crops to other sources	-2.00***	-1.97***	-2.78***	-0.17	-0.67	-0.70	-1.04*	-0.36	-0.43
Livestock to other sources	-3.10***	-1.87	-1.70*	0.42	0.68	-0.14	14.81***	14.97***	16.37***
Other agriculture to other sources	-1.09	-2.33*	-0.26	-1.58*	-0.17	-1.17	-13.37***	-12.50***	-13.16***
Nonfarm activities to other sources	-1.46**	-1.90***	-0.05	-0.62	-0.10	-0.69	0.91	0.78	1.05*
Δ ln distance to service									
Credit	-0.60**	0.66	0.27	-1.14	-0.84*	-0.15	-0.29	-0.44	-0.45
All-weather road	0.35	0.50	-0.50	-1.02	3.32	-0.33	26.45**	30.74**	37.90***
Markets	0.76	0.12	2.39**	-1.72	0.28	-1.11	1.36***	1.50***	1.80***
Perception in 2000-04									
Improved	-1.09**	-0.34	0.51	-0.02	0.45	0.31	0.28	0.24	0.40
Worsened									
Intercept	2.55***	2.39***	1.19**	0.65	-0.20	0.47	-0.21	-0.15	-0.44
Chi-squared	2,208.75	2,053.37	2,979.53	40.14	42.93	39.97	32,479.15	17,565.58	20,799.19

Source of data: Matched sample (based on three nearest neighbor matches) of treatment and nontreatment households from NAADS-IFPRI 2004 and 2007 household survey panel data.

Notes: See Tables 5.1 and 5.2 for a detailed description of the variables. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). The treatment group in each case is NAADS<sub>DIR</sub>. ln: transformation by natural logarithm; Δ: change between 2004 and 2007 values. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance.

**Table A.11—Second-stage multinomial-probit regression results of perception of change in the nutritional quality of food between 2004 and 2007**

Explanatory variables	NAADS <sub>NON-1</sub>			NAADS <sub>NON-2</sub>			NAADS <sub>NON-3</sub>		
	Model I	Model II	Model III	Model I	Model II	Model III	Model I	Model II	Model III
Worsened (cf. no change)									
NAADS	0.32	0.96 **	0.72	0.24	0.58	0.40		1.26 **	
Δ gender of head	0.87	1.87 ***	-0.47	-0.43	-0.79	-0.29		-1.68 **	
Δ ln age of head	-0.22	-0.66	-0.24	0.42	0.40	0.53		1.41	
Δ education (cf. no change)									
Reduction	-0.47	-0.10	-1.53 *	0.62	0.23	0.81 *		-0.89	
Improvement	0.17	-1.15	-0.93	-0.29	0.20	0.09		-1.38 *	
Δ ln household size	0.31	-0.72	0.63	0.67	0.83 **	0.85 **		2.23 ***	
Δ income source (cf. no change)									
Crops to other sources	-1.33 *	1.03	0.86	-0.10	-0.22	0.36		-0.50	
Livestock to other sources	1.12	-1.77	1.28	-0.63	-12.20 ***	-1.87 **		0.02	
Other agriculture to other sources	-2.43 ***	-0.59	0.63	1.51 *	-0.34	-0.58		1.60	
Nonfarm activities to other sources	-0.52	0.01	-0.77	-0.02	-0.01	-0.31		0.33	
Δ ln distance to service									
Credit	1.16 *	0.23	0.86	-0.14	0.51	0.49		-0.07	
All-weather road	1.43 **	-0.48	0.00	-4.89	-8.12 *	-3.11 *		5.20	
Markets	-4.01 **	-0.10	-4.04 **	0.07	0.24	0.45		0.06	
Perception in 2000-04									
Improved	0.34	-1.69 ***	-0.14	-0.35	0.24	-0.05		0.62	
Worsened	-0.19	-0.59	0.23	-0.84 *	0.19	0.04		-0.01	
Intercept	0.87	1.09 **	0.66	1.31 ***	0.68 *	0.85 **		0.12	
Improved (cf. no change)									
NAADS	0.56	1.44 ***	1.12 **	0.81 **	0.97 **	0.85 **		2.21 ***	0.56
Δ gender of head	0.03	2.39 ***	0.28	-0.97 *	-1.15 **	-1.06 **		-0.89	0.03
Δ ln age of head	0.16	-1.72	0.10	0.65	-0.40	0.00		1.85	0.16

(continued)

Table A.11—Continued

Explanatory variables	NAADS <sub>NON-1</sub>			NAADS <sub>NON-2</sub>			NAADS <sub>NON-3</sub>		
	Model I	Model II	Model III	Model I	Model II	Model III	Model I	Model II	Model III
Δ education (cf. no change)									
Reduction	0.05	-0.33	-2.84 ***	0.54	0.43	0.44		-0.59	0.05
Improvement	0.68	-1.73 **	-1.39 *	0.35	1.21	0.76		-0.17	0.68
Δ In household size	-0.33	-0.60	1.19 **	0.71 *	1.00 **	0.95 **		1.89 ***	-0.33
Δ income source (cf. no change)									
Crops to other sources	-0.79	1.51 *	0.90	-0.36	-0.11	0.38		-1.20	-0.79
Livestock to other sources	1.50	-1.92	3.18 ***	-0.43	-1.41	0.45		14.49 ***	1.50
Other agriculture to other sources	-0.25	-0.02	0.18	0.11	-0.20	-0.54		-11.87 ***	-0.25
Nonfarm activities to other sources	0.68	0.55	-1.08 *	-0.62	-0.24	-0.13		0.61	0.68
Δ In distance to service									
Credit	1.63 ***	0.59 **	0.88	-0.79 *	-0.07	0.51		-0.56	1.63 ***
All-weather road	0.11	-0.77 *	-0.18	-6.75	-9.70 *	-2.95		16.66	0.11
Markets	-5.05 ***	0.81	-4.70 ***	0.18	-0.26	0.21		-1.00	-5.05 ***
Perception in 2000-04									
Improved	0.71	-1.22 *	0.57	0.16	0.84 *	0.43		0.33	0.71
Worsened	0.95	0.39	0.92	-0.28	0.97 **	0.99 **		0.09	0.95
Intercept	0.16	0.49	0.26	0.61	-0.40	-0.27		-0.79	0.16
Chi-squared	51.41	48.86	61.44	36.47	4,083.55	49.42		36,655.17	51.41

Source of data: Matched sample (based on three nearest neighbor matches) of treatment and nontreatment households from NAADS-IFPRI 2004 and 2007 household survey panel data.

Notes: See Tables 5.1 and 5.2 for a detailed description of the variables. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). The treatment group in each case is  $NAADS_{DIR}$ . ln: transformation by natural logarithm; Δ: change between 2004 and 2007 values. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance. Elsewhere, blank cells mean not estimated due to limited sample observations across categories of the dependent variable.

**Table A.12—Second-stage multinomial-probit regression results of perception of change in overall wealth between 2004 and 2007**

Explanatory variables	NAADS <sub>NON-1</sub>			NAADS <sub>NON-2</sub>			NAADS <sub>NON-3</sub>		
	Model I	Model II	Model III	Model I	Model II	Model III	Model I	Model II	Model III
Worsened (cf. no change)									
NAADS	-0.27	-0.39	-0.84	-0.31	-0.77 *	-0.76 *	-0.88 *	-0.69	-0.49
Δ gender of head	-1.93***	-0.95	-0.81	-0.12	0.10	0.33	0.42	1.09 *	0.99
Δ ln age of head	-0.44	0.32	-0.10	1.21	1.04	0.03	0.04	-0.09	0.01
Δ education (cf. no change)									
Reduction	-0.49	-0.72	-1.45 *	-0.26	0.02	-0.35	1.16	1.21	1.36
Improvement	-11.21***	0.91	-11.12***	-1.38**	0.91	0.76	0.36	0.80	0.55
Δ ln household size	-0.83	-0.82	0.56	0.22	-0.09	0.08	-0.06	-0.69 *	-0.40
Δ Income source (cf. no change)									
Crops to other sources	-1.60**	-11.36***	-11.26***	-0.33	0.36	0.53	-1.79**	-2.28**	-3.05**
Livestock to other sources	-11.86***	-12.00***	-11.61***	0.43	0.58	0.45	-0.28	-0.18	-0.16
Other agriculture to other sources	-11.42***	-16.22***	-11.91***	0.79	0.04	0.11	-11.58***	-11.34***	-12.02***
Nonfarm activities to other sources	-1.17*	-0.84	-0.58	-0.09	0.49	-0.23	-1.24**	-0.87	-1.12*
Δ ln distance to service									
Credit	-1.06*	-0.32	0.08	-0.29	-0.19	-0.31	-1.70	-1.97	-1.82
All-weather road	0.42	-1.08*	-0.24	-0.93*	-1.04**	-0.22	7.56	11.03	8.49
Markets	0.88	5.50***	-0.22	0.33	-0.04	0.42	0.15	0.21	0.19
Perception in 2000-04									
Improved	1.89***	1.95***	2.22***	-0.41	-0.54	-0.78 *	-1.50**	-1.38**	-1.72***
Worsened	1.37**	0.97	2.33***	-1.06**	-0.45	-1.14**	-0.85	-1.49**	-1.60**
Intercept	-1.70***	-1.55**	-2.11***	-0.02	-0.23	0.34	1.37**	1.46**	1.56**

(continued)

Table A.12—Continued

Explanatory variables	NAADS <sub>NON-1</sub>			NAADS <sub>NON-2</sub>			NAADS <sub>NON-3</sub>		
	Model I	Model II	Model III	Model I	Model II	Model III	Model I	Model II	Model III
Improved (cf. no change)									
NAADS	-0.03	-0.15	-0.27	0.32	0.00	-0.06	0.18	0.50	0.19
Δ gender of head	-0.65	-0.23	-0.87	0.53	0.90*	0.53	-0.73	-0.81	-0.14
Δ In age of head	0.03	-0.51	0.39	-0.79	-0.15	0.09	0.22	0.39	0.31
Δ education (cf. no change)									
Reduction	0.10	-2.07**	-0.93	-0.17	0.33	-0.17	-0.12	-0.14	0.48
Improvement	1.02	0.53	2.70***	0.25	1.29**	1.21**	1.46**	0.98	1.18**
Δ In household size	0.14	0.13	0.94*	0.34	0.30	0.43	0.14	-0.16	0.04
Δ income source (cf. no change)									
Crops to other sources	-0.07	0.19	-1.37**	-0.42	-0.25	-0.03	-0.78	-0.68	-0.70
Livestock to other sources	-0.81	0.77	-1.26	0.29	0.79	-0.75	13.01***	12.57***	12.72***
Other agriculture to other sources	-1.29	0.62	-1.16	-2.20***	-0.95	-0.40	2.25**	0.36	0.24
Nonfarm activities to other sources	-1.26**	-1.41***	-1.63***	-0.33	0.15	-0.06	0.74*	0.77	0.61
Δ In distance to service									
Credit	0.20	-0.08	1.57***	-0.35	-0.11	-0.12	-0.56	-0.70	-0.75
All-weather road	-0.47	0.33	0.24	-0.28	-0.06	-0.14	5.70	8.11	6.05
Markets	0.46	-1.54	-0.61	0.00	-1.30	-0.67	0.78	1.20**	0.85*
Perception in 2000-04									
Improved	0.76	0.86	-0.31	-0.61	-0.16	-0.24	-0.66	-0.12	-0.46
Worsened	1.22*	0.59	1.36**	-0.20	0.02	-0.09	-0.48	-0.65	-0.71
Intercept	-0.05	0.61	0.58	0.58	0.06	0.28	0.51	0.18	0.56
Chi-squared	3,055.19	2,792.51	2,545.21	59.83	36.14	23.57	7,771.61	6,310.88	9,175.87

Source: Matched sample (based on three nearest neighbor matches) of treatment and nontreatment households from NAADS-IFPRI 2004 and 2007 household survey panel data.

Notes: See Tables 5.1 and 5.2 for a detailed description of the variables. Models I, II, and III indicate that the underlying matched subsamples are based on the selection probits using the base model (Model I), the base model plus squared values of some continuous covariates (Model II), and the base model plus interaction terms (Model III), respectively (see Table 5.7). The treatment group in each case is  $NAADS_{DIR}$ . In: transformation by natural logarithm; Δ: change between 2004 and 2007 values. \*, \*\*, and \*\*\* indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively; blank cells in these columns indicate lack of statistical significance.

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**I**N UGANDA, AGRICULTURAL EXTENSION HAS BEEN HOTLY DEBATED SINCE THE IMPLEMENTATION OF the National Agricultural Advisory Services (NAADS) program in 2001. Conceived as a demand-driven approach and largely publicly funded with services provided by the private sector, the NAADS program targets the development and use of farmer institutions. It is a key strategy in the government's poverty-reduction and national development plan.

Due to methodological challenges arising from the complex ways that many factors influence the relationship between extension inputs and outcomes, as well as data-quality issues, the effectiveness of agricultural extension in raising agricultural productivity and incomes and reducing poverty is often viewed with skepticism among policymakers and development practitioners. The NAADS program has been no exception.

Some initial evaluations, mostly qualitative in nature, indicate the program has had a favorable effect on increasing the use of improved technologies, marketed output, and wealth status of farmers receiving services from the program. However, the program does not appear to be promoting improved soil-fertility management, raising concern about the sustainability of potential productivity increases.

Now that the first phase of the program has ended, this study rigorously assesses the outcomes and impacts obtained thus far, in order to help inform the current second phase and offer lessons for others implementing or planning to implement demand-driven agricultural advisory services in developing countries.

The findings presented here are useful to policymakers of central and local governments, farmer groups, advisory service providers, donors, and others seeking to improve agricultural extension services in Uganda and elsewhere. Program evaluators and policy analysts will find the methods instructive.

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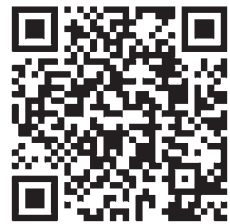
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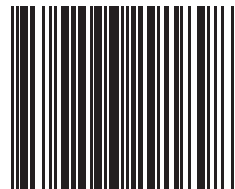
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ISBN 978-0-89629-189-8



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