IMPACT EVALUATION AND RETURNS TO INVESTMENT OF THE NATIONAL AGRICULTURAL ADVISORY SERVICES (NAADS) PROGRAM OF UGANDA

Samuel Benin[1]
Ephraim Nkonya[1]
Geresom Okecho[2]
Josee Randriamamonjy[1]
Edward Kato[1]
Geofrey Lubade[3]
Miriam Kyotalimye[4]
Francis Byekwaso[2]

[1] International Food Policy Research Institute, Washington, DC, USA
[2] National Agricultural Advisory Services Secretariat, Kampala, Uganda
[3] Consultant, Kampala, Uganda
[4] Association for Strengthening Agricultural Research in Eastern and Central Africa, Entebbe, Uganda

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ABBREVIATIONS AND ACRONYMS

CAADP	Comprehensive Africa Agricultural Development Programme
CBA	Cost Benefit Analysis
CBF	Community-Based Facilitators
DANIDA	Danish International Development Agency
DCI	Development Cooperation of Ireland
DFID	Department for International Development
FAO	Food and Agriculture Organization
FEWSNET	Famine Early Warning System Network
FID	Farmer Institutional Development
FEWSNET	Famine Early Warning System Network
GDP	Gross domestic product
GOU	Government of Uganda
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome
GOU	Government of Uganda
IDA	International Development Association
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
ISFG	Integrated Support to Farmer Groups
ITAD	Information, Training and Agricultural Development
LC	Local Community
LG	Local Government
LGFC	Local Government Finance Commission
MAAIF	Ministry of Agriculture, Animal Industries and Fisheries
MAPS	Marketing and Agro-Processing Strategy
M&E	Monitoring and Evaluation
MFPED	Ministry of Finance, Planning and Economic Development
MTTI	Ministry of Tourism, Trade and Industry
NAADS	National Agricultural Advisory Services
NEPAD	New Partnership for Africa's Development
NGO	Non Governmental Organization
NPV	Net Present Value
NRM	Natural Resource Management
NSDS	National Service Delivery Survey
OPM	Oxford Policy Management
PEAP	Poverty Eradication Action Plan
PFA	Prosperity for All
PMA	Plan for Modernization of Agriculture PMA
RDS	Rural Development Strategy
ROU	Republic of Uganda
SDR	Special Drawing Rights
SPCD	Service Provider Capacity Development
RDS	Rural Development Strategy
SSA	Sub-Saharan Africa
SWC	Soil and Water Conservation
SSA	Sub-Saharan Africa
TDS	Technology Development Sites
TLU	Tropical Livestock Unit
UBOS	Uganda Bureau of Statistics
UGX	Uganda Shilling

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EXECUTIVE SUMMARY

Uganda has for a long period of time experienced strong economic growth. In the 1990s, gross domestic product grew steadily by more than 6% per annum from a low rate of 3 percent in the 1980s, and the proportion of the population living under the poverty line declined from 56.4 percent in 1992 to 31.1 percent in 2006. This remarkable turnaround from the depression associated with the political turmoil and economic mismanagement of the 1970's until the mid-1980s has been achieved through sound policies linked to investments and economic liberalization undertaken by the Government of Uganda (GOU) with support from the donor community. Despite the substantial progress made, several challenges remain in sustaining the momentum by way of increasing productivity, ensuring sustainable use of natural resources, and reducing poverty, hunger and human disease. Recognizing the importance of a multi-sectoral approach to accelerating growth and reducing mass poverty, the Government of Uganda has since 2000 been implementing the Plan for Modernization of Agriculture (PMA) as a key policy initiative aimed at reducing mass poverty to a level below 28 percent by 2014. The PMA, which is situated within the country's vision of *Prosperity for All* and is supported by the broader *Rural Development Strategy*, has an ambitious agenda of policy and institutional reform across seven pillars, a key one of which is improving delivery of agricultural extension through the National Agricultural Advisory Services (NAADS) program. Since its inception in 2001, NAADS has devised an innovative extension service delivery approach, that targets the development and use of farmer institutions and in the process empowers them to procure advisory services, manage linkage with marketing partners and conduct demand-driven monitoring and evaluation of the advisory services and their impacts. NAADS was initiated in 2001 in six districts (Arua, Kabale, Kibaale, Mukono, Soroti and Tororo), within which the NAADS program began working in 24 sub-counties. By end of 2006/07 financial year, the program had been extended to 545 sub-counties (about 83.1 percent of the total sub-counties), and is expected to cover the entire country by end of the financial year 2007/08, ending the first phase (Phase I) of the program. By the end of the 2006/07 financial year also, UGX 110 billion (in 2000 value terms) had been spent on the program.

Building on the mid-term evaluation of NAADS (Benin et al. 2007 and others), the overall objective of this study was to undertake 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, and assess the return on investment. This was done using data from two rounds of farmer group and household surveys conducted in 2004 and 2007; where 900 households and 120 farmer groups were surveyed in 2004, and 1200 households and 150 farmer groups were surveyed in 2007, in addition to obtaining secondary data on NAADS expenditures and provision of public services in all the surveyed sub-counties. Most of the households surveyed in 2004 were also surveyed in 2007, giving a panel of 719 households. The surveys were based on a stratified sampling according to the NAADS rollout phases: 1) sub-counties where the NAADS program was first established in 2001/02 referred to as *early NAADS sub-counties*, 2) sub-counties where the NAADS program began in 2002/03 referred to as *intermediate NAADS sub-counties*, 3) sub-counties where the NAADS program began in between 2005 and 2007 referred to as *late NAADS sub-counties*, and 4) sub-counties where there has not been NAADS program, hereafter referred to as *non-NAADS sub-counties*.

Various quantitative and analytical approaches, such as trends, descriptive, double difference, propensity-score matching, and two-stage weighted regression methods, were used 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. Empowerment of farmers to organize themselves and demand and manage agricultural advisory services;
   b. Farmers' perception of the availability, delivery and quality of advisory services;
   c. Farmers' awareness, incidence of adoption 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
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;
4. Assess the return on investment made so far in the program.

Incidence of rural public services among farming households

In general, availability of various rural public services (extension services, input supply shops, markets, roads, schools, health centers, etc.) has improved over time, especially between 2001 and 2007, in terms of presence of physical infrastructure as well as farmers' perceptions of their access to the services. However, availability and access were generally better in the NAADS sub-counties than in the non-NAADS sub-counties. To the extent that these services enhance the impact of the NAADS program, the impact of NAADS is expected to decline as it rolls out to the entire country. Basically, the impacts may tend to be overestimated if differences in availability of services between NAADS-participating and non-participating sub-counties are not adequately controlled for. The results suggest the need of improving rural services in remote areas in order to enhance the returns to NAADS and other investments. For example, one of the weaknesses of the PMA was its failure to strengthen other key rural services such rural financial and marketing services. This has weakened the impact of the NAADS program, especially in the Northern and Eastern regions of Uganda where such services are poor. Notwithstanding their weaknesses, the current efforts through the rural development strategy and prosperity for all to strengthen provision of rural financial and marketing services through cooperatives (MAAIF 2005; GOU 2008) will definitely enhance the impacts of the NAADS program and other rural investments.

Farmer institutional development and empowerment

Overall, we found that the most common areas that farmers had received training in included development of group constitution and bye-laws, leadership skills, growth and development, planning, record keeping, and savings mobilization; with more than 70 percent of the groups in

NAADS sub-counties reporting positively. Also, more groups were trained in the early NAADS sub-counties than in the other sub-counties where the program started later or had not been implemented at all. These suggest that the NAADS program is gradually helping to strengthen the human resource skills and institutional capacity of farmers that will potentially improve natural resource management, agricultural productivity, marketing, etc. This is substantiated by the finding that majority (about 90 percent) of the farmers found the various areas of training to be very useful or useful; although more groups in the early NAADS sub-counties found the training very useful or useful than those in intermediate NAADS sub-counties. NAADS service providers, compared to others, were rated very high on their methods used in the training and on their performance.

In terms of farmers' participation in farmer group activities, we found increasing performance participation to be strongly correlated with period of entry into the NAADS program, with newly NAADS-participating groups reporting better performance. Although false farmer expectations of receiving cash funds and inputs rather than knowledge and advice could have played a significant role in weak group activities and poor farmer empowerment in certain areas, the above finding also suggests a shift in interest among the older NAADS-participating groups from basic agronomic and production practices to higher value-chain activities, such as marketing and value addition. Thus, operationalization of NAADS' strategy regarding gradual introduction of activities along the entire value chain is critical. The higher value chain activities such as marketing should be given more attention, especially among the older groups, as it has consistently featured low in the implementation of the program (Benin et al. 2007).

In general, farmers felt an increase in their level of empowerment, especially toward technical public officers in general. This is very encouraging since technical public officers are well placed to address farmers' agricultural production problems or concerns. However, technical public officers also received the worst performance rating in terms of their response to farmers' requests. While this finding raises concern about the ability to meet farmers' demands, it suggests a weakening of advisory services as the NAADS program rolls out to more districts and sub-counties. A complementary increase in resources to maintain or increase advisory services to those already participating in the program, as well as to new farmers to be taken on board, is therefore critical.

Supply of advisory services

NAADS is an enterprise-based program requiring that farmer groups prioritize their enterprises, which can be a crop, livestock, fishery or beekeeping activity, or a mix of activities, on which advisory services would be focused. As expected, not all enterprises were promoted by NAADS or demanded by farmers everywhere. The major crops promoted by NAADS (and/or requested by farmers) in terms of the number of sub-counties promoted in, or the number of technology development sites (TDSs) established, or the number of farmer groups directly benefiting from the TDSs included banana, groundnuts and rice, followed by vanilla and maize. Regarding livestock and other enterprises, the major ones were goats, poultry and beekeeping, followed by cattle and piggery. Comparing the major crops and livestock enterprises that were promoted by NAADS (and/or requested by farmer), livestock enterprises seemed to be more widely favored.

Decision to participate in the NAADS program

Although the NAADS program is a public investment intervention, farmers have to decide to participate in the program through membership of a NAADS-participating farmer group. Then, together with other groups they demand specific technologies and advisory services associated with their preferred enterprises. We find that the longer the NAADS program has been in a sub-county, the more likely farmers in that sub-county are to directly participate in the program. This means that continued engagement with farmers is critical. One-shot or stop-and-go approaches are not likely to yield any sustained pay-offs. Membership in other organizations, which is a measure of social capital, was also strongly associated with greater likelihood of participation in the NAADS program. This is consistent with the NAADS approach in terms of targeting existing groups to maximize the payoffs from efforts to build farmers' capacity to demand advisory services. Gender, age, education, and income source were not significant factors in determining group membership, which implies that the NAADS program is targeting all socio-economic groups.

Demand for advisory services and adoption of new enterprises and technologies

We find that NAADS has had significant success in increasing the capacity of farmers to demand improved crop varieties, crop management practices, soil conservation, livestock breeds, post-harvest practices and marketing information. This demonstrates that the NAADS demand-driven approach is working. Participation in the NAADS program, however, seem to have lowered the probability to demand soil fertility and agroforestry practices, suggesting low capacity of farmers to demand these technologies and/or weakness of NAADS to provide them. NAADS spent relatively low resources in conducting demonstrations on soil fertility management practices, compared to, for example, acquiring improved planting material. In order to ensure sustainable productivity, NAADS needs to increase the capacity of farmers to demand soil fertility management practices. For example, it may be necessary in the initial stages of demand-driven approaches to supply soil fertility and agroforestry practices in order to build farmers' capacity to demand them.

Crop and livestock productivity and commercialization of agriculture

Consistent with the positive impact on capacity strengthening, demand for advisory services, and adoption of improved technologies, the NAADS program has had significant impact on crop productivity, with the value of gross crop output per acre having increased by up to 29 percent for those participating directly in the NAADS program more than for their non-participant counterparts. The impact of the NAADS program on livestock productivity is surprising, as the results show that the program has contributed to a decline (about 27-45 percent) in the value of gross livestock output per unit of animal among NAADS participants compared to their non-participant counterparts. We find that NAADS has had a small impact on proportion of agricultural output sold by farmers. The impact of the program is estimated to be up to 6 percent increase in crop sales for the NAADS participants over their non-participant counterparts, and up

to 4 percent more sale of total agricultural production. The impact on sale of livestock products is negligible. The NAADS program needs to shift activities away from basic agronomic and production practices towards higher value-chain activities.

Income, consumption expenditure, food and nutrition security, and welfare

NAADS participants were associated with 42-53 percent average increase in their per capita agricultural income compared to their non-participant counterparts. The impact of the program on total agricultural income was more favorable than the income obtained from crops and livestock. This is due to additional substantial income for NAADS participants from high-value agricultural activities such as beekeeping and aquaculture, and demonstrates the effectiveness of the program in diversifying income and promoting more high-value activities. The results also show that significantly larger proportions of NAADS participants than non-participants perceived that their situation had improved, while larger proportions of the non-participants than participants perceived that their situation had not changed or it had worsened. For example, 41–58 percent of all NAADS participants perceived that their average wealth, access to adequate food, nutritional quality of food, ability to meet basic needs or overall wellbeing had improved between 2000 and 2004 and between 2004 and 2007, compared to 27–44 percent of their non-participant counterparts. These results are consistent with the positive impacts of the NAADS program on adoption of improved technologies and agricultural productivity and income, and they suggest the NAADS program has helped farmers to improve their households' standard of living.

Factors affecting realization of impacts

Several factors significantly influenced farmers' demand for advisory services, and changes between 2004 and 2007 in adoption of improved technologies and practices, crop and livestock productivity, sale of output, and income. The main factors include gender and age of the household head, education, income sources, land and non-land productive assets, and access to all-weather roads. There are two main implications of this. First, the impacts of the program tend to be overestimated when these factors are not controlled for. Second, these are the factors that should be considered for targeting to maximize payoffs from the program.

Distribution of impacts

Regional distribution of impacts show that the largest impact of the NAADS program has so far occurred in the Central and Western Regions, where the per capita income of NAADS participants rose by 65-165 percent between 2004 and 2007 compared to their non-participant counterparts, suggesting that the impact of the NAADS program has been more pronounced in the well-off regions. The NAADS program has also had more impact women, when looking at the total impact as opposed to the direct impacts, when men have benefitted more. With regards to the total impacts, women participating in the program were associated with 16 percentage points more increase in their average per capita incomes than men participating in the program.

This suggests that NAADS is only partially achieving its objective of targeting women, a group that has attracted little resources and experienced limited access to agricultural extension in SSA. The distribution of impacts by asset-endowment tercile shows that the NAADS program has been more successful at raising income among the poorest households, where the per capita income of those participating in the program more than doubled between 2004 and 2007 compared to their non-participating counterparts. This was followed by the richest group, where per capita income of participants grew by nearly 36–40 percent within the same time period. These suggest that NAADS is achieving its objective of targeting the economically-active poor. However, the fact that the richest participants benefited more than those in the middle asset class underlies the importance of household's capacity to acquire the improved technologies and related advisory services being promoted by the NAADS program.

Returns to investments

Based on the gross agricultural income per capita, the total benefits of the NAADS program in the 37 NAADS-participating sub-counties that were surveyed was estimated at UGX 49.7-54.8 billion. The total cost was estimated at UGX 14.4 billion, indicating a benefit-cost ratio of about 5. This means that every UGX 1 spent on the NAADS program so far has yielded UGX 5 in terms of its contribution to agricultural income. On accounting for the cost of agricultural inputs and operations, which were estimated at about 35 percent of the gross income, the discounted total benefits dropped to UGX 32.1-35.4 billion. Similarly, accounting for the interest payments on the loans acquired to finance the program led an additional cost of UGX 2.4 billion (or 16.8 billion total), which together with the reduced benefits reduced the benefit-cost ratio to about 2.5.

Issues for future research

Although the study tried to capture many important issues regarding the benefits and costs of the program to assess the economic returns, a few issues remain that future research can improve upon. These relate to general equilibrium effects, complementarity (or substitutability) of public investments, and other benefits. For example, the scaling out of the NAADS program to all parts of the country is likely to affect relative prices and may require additional taxes to pay back the loan obtained to finance the program. Both effects mitigate the impact of the program, potentially leading to an overestimation of benefits based on partial equilibrium analysis. Similarly, strengthening the capacity of farmers and service providers also will affect the skill composition of the labor force and service providers, which in turn will affect the wage structure and cost of advisory services. Thus, including economic modeling techniques in future analysis will prove useful.

Another issue is the complementarity (or trade-offs) between the NAADS program and other different types of public investments. For example, we would anticipate complementarity between investment in the NAADS program and investments in agricultural R&D and education. This is because agricultural technologies tend to be highly complex, knowledge intensive, and location specific, and so technologies that are profitable under local conditions and knowledge and skills are required for the success of the program. Typically, interaction terms among the

relevant investments can be included in the regression model to capture these effects; and to the extent that complementarity (substitutability) exists, the benefits would be overestimated (underestimated). Due to the small sample size of the survey data used in the study, interaction terms could not be included in the regressions as doing so can introduce severe multicollinearity, which would then cause the regression parameters to be estimated imprecisely.

The NAADS program can be expected to generate a range of other benefits that have not been considered here nor assessed quantitatively. These include the improved human resource skills associated with training and strengthening of local institutional capacity. For example, training on technical and managerial areas that are provided to private service providers, extension staff, subject matter specialists, and research staff will develop improved skills, which would contribute to productivity improvements not only on the farm but off it. Training of village groups, community-based facilitators, farmer contact groups, and farmer fora at the local level will strengthen local institutional capacities and empower farmers to effectively demand advisory services. The improvements in both the human resource skills and institutional capacity will generate benefits when also used in non-agricultural economic and non-economic activities.

1. INTRODUCTION

Uganda has for a long period of time experienced strong economic growth. In the 1990s, gross domestic product (GDP) grew steadily by more than 6 percent per annum from a low rate of 3 percent in the 1980s, and the proportion of the population living under the poverty line declined from 56.4 percent in 1992 to 31.1 percent in 2006 (UBOS 2006). This remarkable turnaround from the depression associated with the political turmoil and economic mismanagement of the 1970's until the mid-1980s has been achieved through sound policies linked to investments and economic liberalization undertaken by the Government of Uganda (GOU) 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 sustainable use of natural resources, and reducing poverty, hunger and human disease. Recently agriculture has not performed as well as the rest of the economy. For example, from 2000 to 2005 agriculture GDP grew by 4.5 percent per year compared to 5.6 percent for the entire economy (World Bank 2007). Also, while the incidence of poverty has declined, it is still substantially higher in rural rather than urban areas, 34.2 percent compared to 13.7 percent, respectively (UBOS 2006).

Recognizing the importance of a multi-sectoral approach to accelerating growth and reducing mass poverty, the Government of Uganda has since 2000 been implementing the Plan for Modernization of Agriculture (PMA) as a key policy initiative aimed at reducing poverty to a level below 28 percent by 2014 (MFPED 2004). The PMA, which emphasizes the revitalization of agriculture as an engine of growth and development for the economy, is situated within the country's vision "Prosperity for All" (PFA) and is supported by the broader Rural Development Strategy (RDS). This attempt to accelerate poverty reduction through agricultural growth is not surprising since 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 2007). 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 (CAADP), which provides an integrated framework of development priorities aimed at restoring agricultural growth, rural development and food security, which again is consistent with the PMA. The main target of CAADP is achieving six percent agricultural growth per year supported by the allocation of at least 10 percent of national budgetary resources to the agricultural sector.

The PMA, whose overall objective is to enhance production, competitiveness and incomes, has an ambitious agenda of policy and institutional reform across seven pillars, a key one of which is improving delivery of agricultural extension through the National Agricultural Advisory Services (NAADS) program (MFPED 2004). The provision of agricultural extension and other agricultural support services became the responsibility of local governments in 1997, as per the Local Government (LG) Act of 1992 (LGFC (1997) cited in Livingstone and Charlton (2001)). The decentralization faced several challenges. For example, the proportion of district budgets allocated to agricultural production and marketing in three districts studied by Francis and James (2003) was 3 percent or less, while at the sub-county 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 et al. 2002), which is surprising. More generally, lack of funds and equipment seem to be the main constraints to facilitating the work of extension agents at the local government level (Sserunkuuma et al. 2001).

Realizing the financial and human resource weaknesses and the top-down approach of the traditional extension services, the Government of Uganda initiated the demand-driven NAADS program as the key strategy to implement the PMA strategy. Since its inception in 2001, NAADS has devised an innovative extension service delivery approach, that targets the development and use of farmer institutions and in the process empowers them to procure advisory services, manage linkage with marketing partners and conduct demand-driven monitoring and evaluation (M&E) of the advisory services and their impacts. The NAADS program has been one of case studies of decentralization of agriculture that uses the new demand-driven advisory services, in which the private providers are given a key role in providing agricultural advisory services in sub-Saharan Africa (SSA). The NAADS program has been operating in the past seven years and this study was conducted to assess its impact on empowerment of farmers, adoption of agricultural technologies, crop and livestock productivity, and household income. These outcomes are assessed across gender and administrative regions of Uganda. The study also evaluates the returns to investment in the NAADS program. Besides informing the (design and) implementation of NAADS Phase II, i.e. the scaling up of the program over the next several years to all parts of the country, the results of the study will be useful for drawing potential lessons for other countries in sub-Saharan Africa (SSA) and other developing countries implementing or planning to implement demand-driven agricultural advisory services. The findings of this study are expected to be useful to policy makers of the central and local governments, farmer groups, advisory service providers, donors and others seeking to improve agricultural extension services in Uganda and elsewhere.

1.2. Role of NAADS

The National Agricultural Advisory Services (NAADS) program is a 25-year program with an initial phase of 7 years. 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 specific objectives are (MAAIF and MFPED 2000):

1. Increasing effectiveness, efficiency and sustainability (including financing, private sector participation, farmer responsiveness, deepening decentralization, and gender sensitivity) of the extension delivery service;
2. Increasing farmers' access to and sustaining knowledge (education), information and communication to the farmers;
3. Increasing access to and sustaining effective and efficient productivity-enhancing technologies to farmers;
4. Creating and strengthening linkages and co-ordination 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 are farmer organizations, local governments, private sector, NGOs, Board of Directors, Secretariat, the Ministry of Finance, Planning and Economic Development (MFPED) and the Ministry of Agriculture Animal Industry and Fisheries (MAAIF). The Secretariat is responsible for providing technical guidance and operational oversight to implementation of the program and facilitating outreach and impact. Empowering farmers, targeting the poor, mainstreaming gender issues and deepening decentralization are some of the key defining principles of NAADS (NAADS Secretariat 2000). The NAADS program targets 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. The Secretariat works with farmer groups to contract and supervise private professional firms to provide specialized services according to farmers' priority needs. There is a coordinator at the district (LC5) level who works with the sub-county (LC3) and the local community (LC1) to identify priorities, manage allocation of contracts, and monitor and evaluate performance and accountability of service providers and farmer groups.

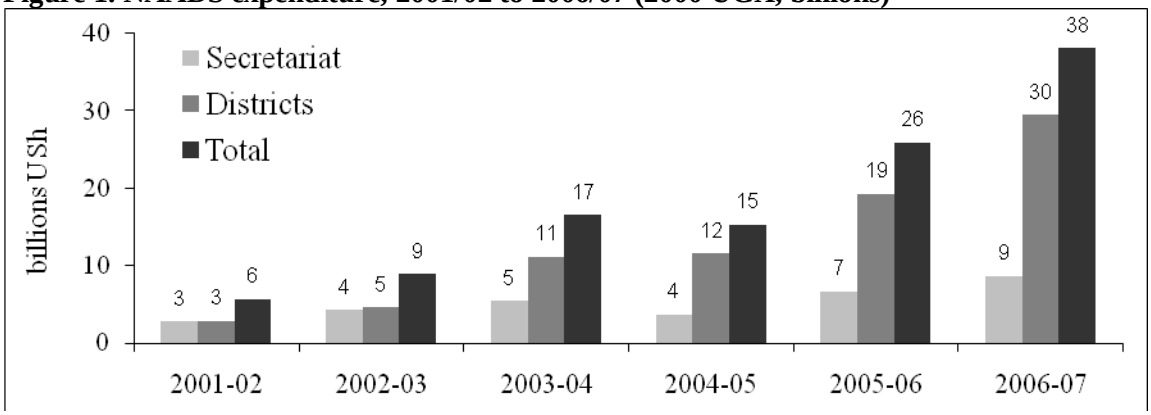
NAADS was initiated in 2001 in six districts (Arua, Kabale, Kibaale, Mukono, Soroti and Tororo), within which the NAADS program began working in 24 sub-counties. By end of 2006/07 financial year, NAADS had extended to 545 sub-counties (about 83.1 percent of the total sub-counties). The program is expected to cover the entire country by end of the financial year 2007/08. By the end of the 2006/07 financial year, NAADS had spent USh110 billion (in 2000 value terms). Initially, spending was equal between the Secretariat and districts and sub-counties (or local governments). This is expected as the Secretariat handled many of the functions (e.g. procurement) on behalf of the districts and sub-counties at beginning of implementation. Over time, however, spending shifted away from the Secretariat towards the districts and sub-counties (Figure 1), as districts and sub-counties took over their functions, and as more districts and sub-counties were added to the program. In the 2006/07 financial year for example, nearly 80 percent of the total allocation was spent at the district (and sub-county) level (Figure 1).

Development partners contributed the bulk (nearly 80 percent) of the amount spent, with the Government of Uganda and farmers contributing the remaining 20 percent (Figure 2). Local governments and farmers contributed 4 percent and 2 percent, respectively.[1] The development partners include international Development Association (IDA, 49.8 percent), International Fund for Agricultural Development (IFAD, 19.3 percent), European Union (EU, 18.1 percent), Netherlands (5.8 percent), Development Cooperation Ireland (DCI, 3.8 percent), Danish International Development Agency (DANIDA, 2.2 percent), and Department for International Development (DFID, 0.9 percent)[2].

[1] This does not include the in-kind contribution of community-based facilitators (CBFs) in terms of the opportunity cost of their time spent extending advisory services to farmers in the community. This is dealt with later when we analyze the benefit-cot ratio of the program.

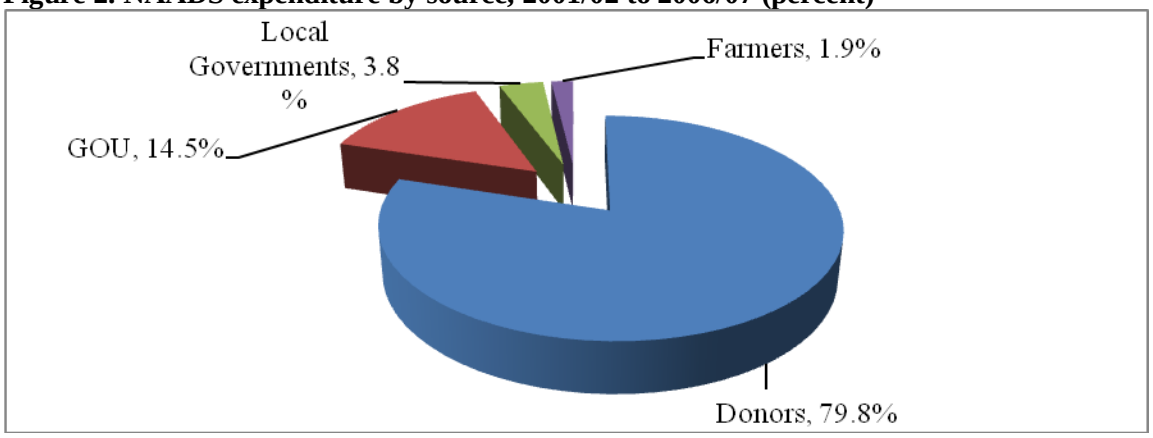
[2] DFID stopped contributing directly to the NAADS program in the 2004/05 financial year, but provides non-earmarked budget support to the GOU.

Figure 1. NAADS expenditure, 2001/02 to 2006/07 (2000 UGX, billions)



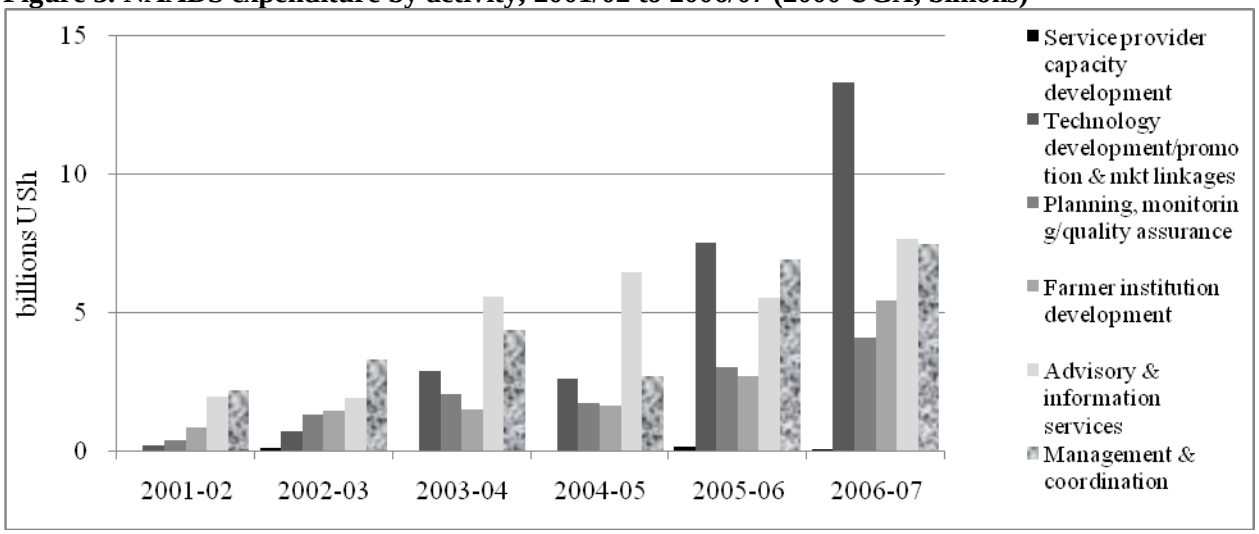
Source: NAADS Secretariat

Figure 2. NAADS expenditure by source, 2001/02 to 2006/07 (percent)



Source: NAADS Secretariat

Figure 3. NAADS expenditure by activity, 2001/02 to 2006/07 (2000 UGX, billions)



Source: Author's calculation based on data from NAADS Secretariat.

Figure 3 shows what the funds has been spent on. 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 on farmer institutional development (16 percent in 2001/02). As the program matured, spending on technology development and monitoring and evaluation increased, 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.

Initial evaluations of the NAADS program have been quite favorable in terms of increase in use of improved technologies, marketed output, and wealth status of farmers receiving services from NAADS (Scanagri 2005; OPM 2005; Nkonya et al. 2005; Benin et al. 2007). But some of the previous findings also show NAADS does not appear to be having success in promoting improved soil fertility management, raising concern about the sustainability of potential productivity increases (Benin et al. 2007). As the current phase of the NAADS program (henceforth NAADS Phase I) comes to an end in June 2008 financial year, it is important to assess the outcomes and impacts of NAADS Phase I and its contribution to food security, poverty reduction and environmental degradation. The results would help inform the (design and) implementation of the second phase (henceforth NAADS Phase II) that is underway (see *http://www.naads.or.ug/news.php?id=88*).

1.3. Aims and objectives of this study

Building on the mid-term evaluation of NAADS (Benin et al. 2007 and others), the overall objective of this study is to undertake a rigorous end-of-Phase 1 evaluation of the NAADS program to analyze and document the outcomes and the direct and indirect impacts of the program, as well as return on investment. 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. Empowerment of farmers to organize themselves and demand and manage advisory services;
    b. Farmers' perception of the availability and delivery of advisory services;
    c. Farmers' awareness and 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
3. Analyze and quantified 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;
4. Assess the return on investment made so far in the program; and
5. Establish a database for conducting future impact studies.

In the next section we present the conceptual framework for assessing the outcomes and evaluating the direct and indirect impacts of the NAADS program. This is followed in section 3 by the data and methods used for the evaluation. The results are presented in sections 4 and 5, first looking at the landscape within which the NAADS program is implemented and the delivery of and demand for advisory services in Uganda. This is then followed by impact of NAADS on several outcome and impact indicators, as well as an analysis of several factors that influence achievement of the outcomes and impacts. In section 6, we present benefit-cost analysis of NAADS investments to date. Conclusions and recommendations are presented in section 7.

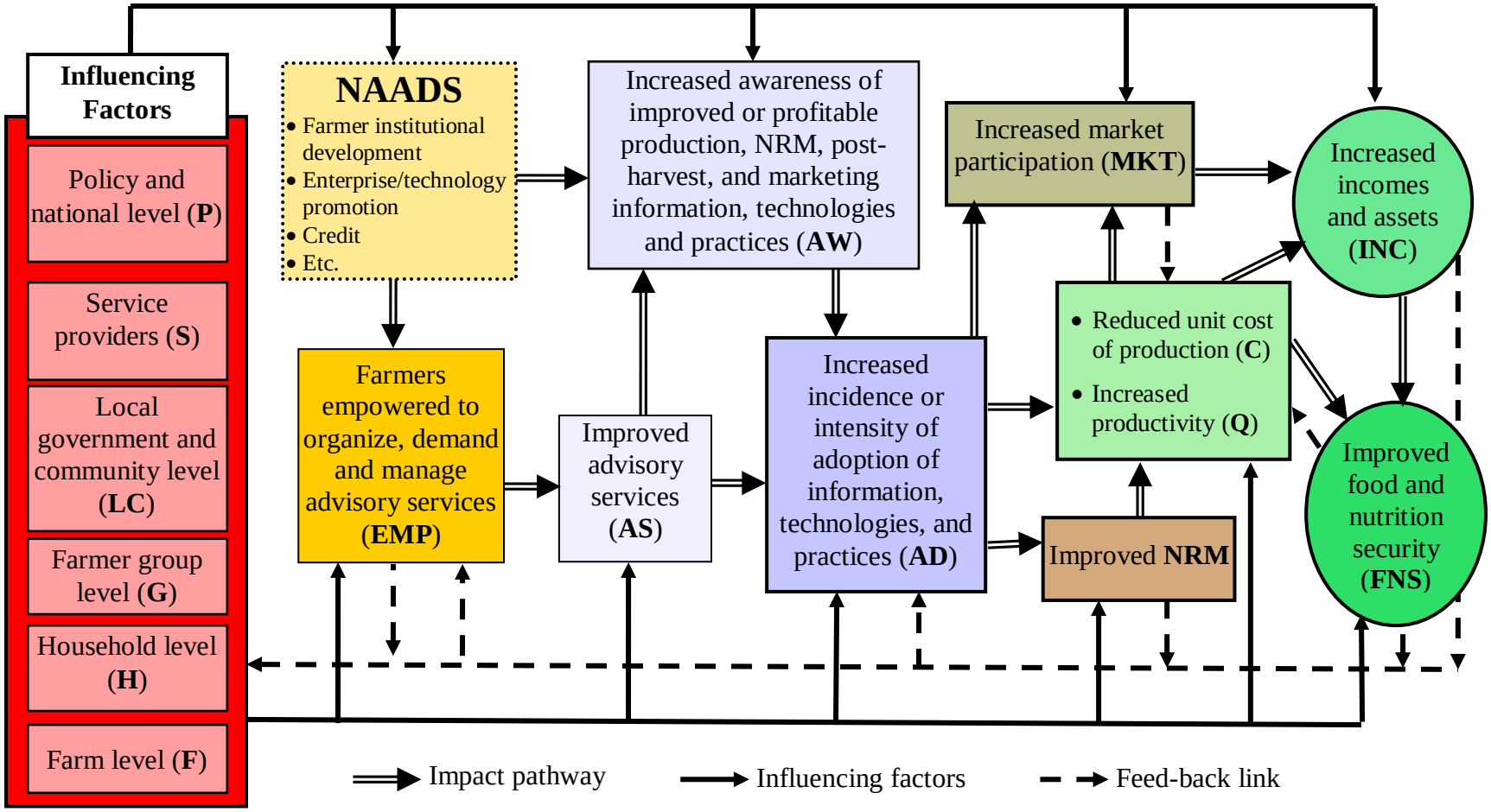
2. CONCEPTUAL FRAMEWORK

The relationships (or the pathways of impact) between the NAADS program and agricultural productivity, incomes and food insecurity is shown in Figure 4. By empowering farmers to demand and manage advisory services, the NAADS program is expected to lead to improved advisory services and increased adoption of technologies, information and practices by farm households, which in turn leads to improved natural resource management, increased market participation, and increased productivity. Increased agricultural productivity (including reduced unit cost of production) in turn contributes to higher incomes and assets, reduced poverty, and improved food and nutrition security. By increasing the awareness of improved or profitable enterprises, technologies and practices, which in turn leads to increased adoption of those technologies and practices, the NAADS program also reinforces the above linkages.

However, whether farm households actually do adopt the enterprises, technologies, practices or information being promoted depends on their ability to adopt them, which is influenced by their constraints of several household– and farm–level factors, including land, labor, capital, other assets, credit, livelihood options, and so forth. (Feder et al. 1985; Feder and Umali 1993). These factors are typically shaped by local government factors as well as national-level and policy factors typically associated with infrastructure development, availability of nonfarm employment opportunities, prices, etc. For example, availability of off-farm employment opportunities (or off-farm income) contributes to agricultural income by providing resources to hire labor or to purchase inputs. On the other hand, off-farm opportunities may reduce farmers' incentive to invest in agriculture in general (and adoption of NAADS technologies in particular), as they become less dependent on the land and as the opportunity costs of their labor and capital are increased by having access to profitable alternatives (Nkonya et al. 2004; Holden et al. 2001). However, whether such changes result in more or less agricultural productivity, for example, depends on the extent to which the technologies and practices being promoted are suited to the labor and capital constraints of households. It may also depend on how well local markets, institutions and policies function to relax or increase the constraints facing households. For example, where markets are imperfect, production decisions are not separable from consumption preferences (Singh et al. 1986; de Janvry et al. 1991); and so preference of certain producer groups for certain types of foods may greatly affect the production system, independently of considerations of profitability and comparative advantage.

The realization of impacts (e.g. higher agricultural productivity, higher incomes, reduced poverty, improved food and nutrition security, etc.) may also be influenced by factors beyond the household's control. For example, agricultural production will depend on agro-ecological and bio-physical factors. In general, livelihoods may be influenced by many village level factors, 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 and returns to alternative income-generating activities, both on and off the farm.

Figure 4. NAADS impact pathways



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 government programs, policies, and institutions may influence the pathways at various points. For example, macroeconomic, trade, and market liberalization policies will affect the relative prices of commodities and inputs in general throughout a nation. Agricultural research policies affect the types of technologies that are available and suitable to farmers in a particular agro-ecological region. Infrastructure development, land tenure policies, and rural credit and savings programs affect awareness, opportunities, or constraints at the village or household level.

3. METHODOLOGY

3.1. Surveys and Data Collection

This study uses data from two rounds of farmer group and household surveys conducted in 2004 and 2007. The 2004 data served as the baseline on which a stratified sampling is based according to the NAADS rollout phases: 1) sub-counties where the NAADS program was first established in 2001/02, hereafter referred to as "*early NAADS sub-counties*", 2) sub-counties where the NAADS program began in 2002/03, hereafter referred to as "*intermediate NAADS sub-counties*", 3) sub-counties where the NAADS program began in between 2005 and 2007, hereafter referred to as "*late NAADS sub-counties*", and 4) sub-counties where there has not been NAADS program, hereafter referred to as "*non-NAADS sub-counties*". The late NAADS stratum was created during the second round of the survey from the non-NAADS stratum of the first round survey. [3] This was necessary since the NAADS program had begun operating in some of the areas where they were not operating in 2004, i.e. at the time of the first round survey. Therefore, new farmer groups and households were also surveyed to increase the sample in the non-NAADS stratum.

Table 1 shows the number of households and farmer groups sampled from each stratum in each survey year. All the six early NAADS districts and the 24 corresponding sub-counties were selected for survey. In the case of the intermediate NAADS group, four of the nine districts and 18 of the 72 sub-counties were sampled. The districts and sub-counties from the intermediate and late NAADS group as well as from the non-NAADS group were purposively sampled such that they had similar agricultural potential[4] and market access[5] as the corresponding early NAADS districts and sub-counties. For each of the early NAADS districts, a matching district, i.e., one with similar market access and agricultural potential setting, from the other strata was selected. This was done to minimize the across group variation in agricultural potential and market access, which are likely to greatly influence agricultural production, income and other outcomes of interest that will be analyzed in this study. From each selected sub-county, two parishes were randomly selected, and then from each selected parish one village (LC1) was randomly selected. From each of the selected villages, 6-13 households were randomly selected. 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 1200 households and 150 farmer groups were surveyed in 2007, with a panel of 719 households and 110 farmer groups (Table 1).

The data collected from the household survey include the demographic and socio-economic characteristics of the household. To understand the impact of the NAADS program on adoption and productivity of new technologies and enterprises, data on awareness and use of improved production practices and new enterprises adopted after 2000 in the 2004 survey and after 2004 in

[3] See Benin et al. (2007) for details on the sampling in the first round survey.

[4] 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.

[5] 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.

the 2007 survey were collected at household level. The information is differentiated according those introduced by NAADS and non-NAADS service providers. The household survey also collected data on participation of households in the market and their access to advisory services and other institutions. Other data collected include agricultural production data, income strategies, and perception of change in wealth and food and nutrition security. Production cost data was also collected, but only in the 2007 survey. To get a sense of what the situation was before the program started in 2001, the 2004 survey was also used to collect information on key factors and outcomes in 2000 (particularly on perception of change between 2000 and 2004) in assets and agricultural production, as well as in wealth and food and nutrition security.

Table 1: Number of districts, sub-counties, villages, farmer groups and households sampled in each NAADS rollout phases

Survey year/sampling units	Early NAADS (2001/02)	Intermediate NAADS (2002/03)	Late NAADS (2005-07)	Non-NAADS	Total
2004					
Districts	6	4	0	4	14
Sub-counties	24	18	0	16	58
Villages	48	36	0	32	116
Farmer groups	48	36	0	32	116
Households	402	300	0	200	902
2007					
Districts	6	4	2	6	18
Sub-counties	24	18	4	27	73
Villages	48	36	6	60	150
Farmer groups	48	36	6	60	150
Households	402	300	81	417	1200
Panel (2004 and 2007)					
Districts	6	4	2	2	14
Sub-counties	24	18	4	12	58
Villages	48	36	6	26	116
Farmer groups	48	36	6	20	110
Households	323	202	81	113	719

The farmer group survey collected data related mainly to empowerment of farmers to organize, to demand and manage advisory services and how advisory services of different types have influenced livelihoods of female and male farmers. Other data collected in the farmer group survey include access of group members to advisory services, their participation in development of institutions and their perception on the quality and availability of advisory services.

In the second round of data collection, secondary data was also collected at the sub-county level on infrastructure and public service provision, NAADS' processes on farmer institutional development, service provider contracts, technology development sites and demonstrations, and NAADS' expenditure.

In the analysis, all monetary values are converted into 2000 constant prices using the consumer price index as the deflator. This helps to exclude the influence of inflation and other temporal monetary and fiscal trends. All statistics are also corrected for stratification, clustering, and weighting of sample. The clusters were the villages and sampling weights were calculated using parish level human population data. Sample weights are inverse of the probability of a household

being selected in the sample, which was calculated as (the number of selected parishes divided by the total number of parishes in the sub-county) multiplied by (the number of selected households divided by the total number of households in the parish). Since population data were only available at the parish (not village) level, random selection of households at the parish level was assumed in the calculation. Due to the nature of the sampling, the results are representative only of the selected sub-counties, since these were purposively selected.

3.2. Estimation and Determinants of Outcomes and Impacts

Data from the two rounds of surveys are analyzed using different methods to assess the outcomes and impacts of the NAADS program, as well as the factors contributing to achieving the outcomes and impacts. The main challenge with estimating the impacts NAADS, as with any other program evaluation study, is with the attribution of change in the relevant indicator to the NAADS program. If we let *y* represent the set of outcome indicators of interest to the study, 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 they had not participated in the program. This difference or the impact of treatment, i.e. Average Treatment effect of the Treated (ATT_j) can be represented as:

$$ATT_j = E\left[y_{1j} \middle| NAADS_j = 1\right] - E\left[y_{0j} \middle| NAADS_j = 1\right] \quad \ldots\ldots\ldots\ldots(1)$$

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 he or she had not participated in the NAADS program. Unfortunately, we cannot observe the counterfactual, i.e., the value of the outcome of farm household if he or she had not participated in the program. In addition, since individuals may choose to participate or not participate in the program, those who choose to participate are likely to be different from those who choose not to participate. These differences, if they influence the outcome, may invalidate the results from comparing outcomes by treatment status, possibly even after adjusting for observed covariates. Several methods have been employed to deal with these issues; ranging from traditional approaches, including fixed-effect methods from panel data analysis and instrumental variables methods, to experimental and quasi-experimental methods that tries to establish alternative scenarios to represent the counterfactual.[6] Using the data on the program participants and non-participants, we estimate the *ATT* associated with several outcomes using different methods and combination in order to provide a robust assessment of the impacts of NAADS.

The underlying estimation problem can be represented as a treatment-effects model of the form:

$$y_{jt} = \alpha_j + \tau_t + \boldsymbol{\beta}' \boldsymbol{x}_{jt} + \delta NAADS_j + \epsilon_{jt} \quad \ldots\ldots\ldots\ldots(2)$$

$$NAADS_j^* = \boldsymbol{\gamma}_j'^{\mathrm{w}} + \mu_j$$

[6] See Imbens and Wooldridge (2008) for review of issues and methods in program evaluation.

$$NAADS_j = \begin{cases} 1, & if\ NAADS_j > 0 \\ 0, & otherwise \end{cases} \quad \text{.....(3)}$$

Where: x_j and w_j are the vectors of independent variables affecting the outcome and the decision to participate in the NAADS program, respectively; $NAADS_j = 1$ and $NAADS_j = 0$ represent participation and non-participation in the program, respectively; α and τ capture the individual and time specific effect, respectively; β and γ are the vectors of parameters measuring the relationships between the dependent and independent variables; and ϵ and μ are the random components of the respective equations with bivariate normal distribution of mean zero and covariance matrix $\begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix}$, where $\rho = \text{cov}(\epsilon_{jt}, \mu_j)$.

As stated earlier, the main issue here is that farm households self-select in participating in the NAADS program through membership of a NAADS-participating farmer group. Therefore, assessing the impacts (i.e. $\hat{\delta}$.) from estimation of equation (2) by ordinary least squares (OLS) methods is likely to result in under-estimation or over-estimation of the benefits of the program.[7] We anticipate that the benefits from estimation by OLS are more likely to be under-estimated given the public good nature of the program. This is because the main intervention point of the NAADS program is through technology development sites (TDSs) and demonstrations that are open to all farmers irrespective of whether they are members of a NAADS-participating farmer group or not. In other words, the program is expected to generate large spillover effects. We estimate $\hat{\delta}$ using different methods, which are discussed in the upcoming subsections, in order to provide a robust assessment of the impacts of NAADS.

3.2.1. Difference-in-differences method

The difference-in-differences (DID) or double differencing method measures the average gain or change in outcome over time in the treatment group less the average gain or change in outcome over time in the control group. 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 NAADS using this method can be obtained by estimating a difference equation of equation (2) above by OLS without the covariates according to:

$$\Delta y_j = \bar{\alpha} + \hat{\delta}_{DID} NAADS_j + e_j \quad \text{.....(4)}$$

$$\Delta y_j = \bar{\alpha} + \hat{\delta}_{DIDT} NAADS_j + y_{jt0} + e_j \quad \text{.....(5)}$$

[7] Note that since the NAADS program is rolled to a few districts and sub-counties each year, we do not observe the participation decision of farmers in areas where the program is not being implemented. This implies that the participation decision variable ($NAADS_j$) is truncated when considering the data and observations from the non-NAADS sub-counties (see discussion on surveys and data collection). One way to deal with this problem is to directly model the decision of where to place the program. Since we do not have the data to empirically model and estimate this, we deal with the problem by excluding the data from the non-NAADS sub-counties in 2007.

Where the impact ($\hat{\delta}_{DID}$) estimated from equation (4) does not exploit the specific features of the panel data, but the impact ($\hat{\delta}_{DIDT}$) estimated from equation (5) does. Where $\Delta y = y_{t1}$ 愀y_{t0}, and y_{t1} and y_{t0} are the outcomes in the first and second period, respectively. We used the DID method to estimate the effect of NAADS on several outcome and impact indicators, including adoption of technologies, crop productivity, livestock productivity, and agricultural income per capita. Depending on the years that we have data on outcome and impact indicators, we estimate change in the values of the indicators between 2000 and 2004, 2004 and 2007, and 2000 and 2007. The main drawback with the DID method of assessing the impacts is that other factors likely to affect the participation decision as well as the realization of the outcomes and impacts are not controlled for.

3.2.2. Propensity score matching method

The propensity score matching (PSM) method, which is a now commonly used quasi-experimental method in program evaluation, addresses the shortfalls mentioned above by trying to select program participants and non-participants who are as similar as possible in terms of observable characteristics that are expected to affect participation in the program as well as the outcomes.[8] 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 non-participants using a propensity score, which is the estimated conditional probability of being included in the program.[9] Only NAADS participants and non-participants that have comparable propensity scores or have matches are used in the estimation. Those that do not have comparable propensity scores or have no matches are dropped. After selecting the comparable subgroups, the counterfactual of each participant, i.e. the value of the outcome if the participant had not participated in the program ($\hat{y}_{0j}[\square|NAADS]_j = 1$), is imputed as the average of the observed outcomes of the participant and non-participant matches. Similarly, the counterfactual of each non-participant, i.e. the value of the outcome if the non- participant had participated in the program ($\hat{y}_{1j}[\square|NAADS]_j = 0$), is imputed as the average of the observed outcomes of the non-participant's participant matches. Assuming i=1, 2,…M matches for the jth observation, then:

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

$$\hat{y}_{1j} = \begin{cases} \frac{1}{M} \sum_{j \in \mathcal{J}_M(i)} \square y_j, & NAADS_j = 0 \\ y_j, & NAADS_j = 1 \end{cases} \qquad \text{……(6)}$$

[8] This method is referred to as a "quasi-experimental" method because it seeks to mimic the approach of experiments in identifying similar "treatment" and "control" groups. However, since the comparison groups identified in PSM 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 (2008) for review.

[9] See Becker and Ichino (2002) on how to implement the PSM method.

The difference estimator is then used to estimate the impact of NAADS or the *ATT* (i.e. $\hat{\delta}_{PSM}$) according to:

$$\hat{\delta}_{PSM} = \sum_{j} w_j \left(\hat{y}_{1j} - \hat{y}_{0j} \right) \quad \text{.....(7)}$$

Where w_j are weights based on propensity scores. Therefore, the PSM method requires econometric estimation of equation (3) only, using a binary dependent variable model (probit or logit) to predict the conditional probability of being in the treatment group. The independent variables typically used for computing the propensity scores are those which jointly affect participation in the treatment as well as the outcomes. In this study, we used the probit model and selected factors that affect participation in the NAADS program as well as those that affect adoption of technologies, agricultural production, and household income. Besides using the conceptual framework to guide selection explanatory variables for the probit model, the "balancing test" (Dehejia and Wahba 2002) is also used to justify inclusion of the variables based on the statistical significance of the difference in the means of each variable between the two groups, i.e. NAADS participants (treatment) and non- participants (control). To provide a robust assessment of the impacts of the program using this method, we employ different matching techniques: kernel matching, where all the treated individuals are matched with a weighted average of all controls using weights that are inversely proportional to the distance between the propensity scores of the treated and controls (Becker and Ichino 2002); and covariance and nearest-neighborhood matching, where each treated individual is matched with controls with the closest propensity score, i.e. nearest neighbor, while accounting for the difference in the mean values of the covariates between the treated and controls (Abadie and Imbens 2006 and 2007). We expect better estimates with the latter and with increasing number of neighbors used in the matching.

Although only the results of equation (3) are used, the estimator nets out the effects of any factors (whether observable or unobservable) that have fixed (or time-invariant) and additive impact on the outcome indicator. Also, using PSM avoids having to deal with potential problems associated with estimating equation (2), including identification and endogeneity of other variables. We use the PSM method to estimate the *ATT* for several outcome and impact indicators, including frequency of extension visits received, adoption of technologies, crop productivity, livestock productivity, and agricultural income per capita.

The main limitation of using the PSM method arises from the assumption that there is no unobserved heterogeneity, i.e. there is no bias arising from unobserved factors or that the bias arising from unobservable factors remains constant through time. With the PSM method also, we are unable to analyze factors other than participation or non-participation in the NAADS program that contribute to achieving the outcomes and impacts. This is taken up next.

3.2.3. Two-stage weighted regression method

To analyze the contribution of other factors in achieving the outcomes and impacts (or estimate $\boldsymbol{\beta}$ in equation 2), a regression method is necessary. Because of the potential correlation between the covariates ($\boldsymbol{x}_j$) and the treatment ($NAADS_j$), the conventional methods that are available for estimating equation 2 (e.g. fixed-effect methods with panel data analysis and instrumental

variables methods available) are not sufficient. Thus, it becomes natural to combine PSM and regression methods in a two-stage procedure (Robins and Rotnitzky 1995; Robins, Rotnitzky and Zhao 1995; Imbens and Wooldridge 2008). Equation (3) is first estimated to obtain the propensity scores, which are then used as weights in a second-stage estimation of equation (2). Basically, we apply a two-stage weighted regression (2SWR), using the propensity scores as weights, to estimate:

$$\Delta y_j = \hat{\alpha} + \hat{\boldsymbol{\beta}}'_{2SWR}\Delta \boldsymbol{x}_j + \hat{\delta}_{2SWR} NAADS_j + e_j \quad \text{.....(8)}$$

$$\Delta y_j = \hat{\alpha} + \hat{\boldsymbol{\beta}}'_{2SWRT}\Delta \boldsymbol{x}_j + \hat{\delta}_{2SWRT} NAADS_j + y_{jt0} + e_j \quad \text{.....(9)}$$

Where, similar to the DID regressions, equation (8) does not exploit the specific features of the panel data, but equation (9) does. Since the weighting can be interpreted as removing the bias due to any correlation between $\boldsymbol{x}_j$ and $NAADS_j$, and the regression isolates the effect of $\boldsymbol{x}_j$ over time, the impact of NAADS or the *ATT* (i.e. $\hat{\delta}_{2SWR}$ or $\hat{\delta}_{2SWRT}$) estimated with this two-stage weighted regression is doubly-robust (Imbens and Wooldridge 2008).

We use this two-stage weighted regression method to estimate the impact of NAADS as well as analyze the contribution of various factors affecting: (i) demand by farm households for advisory services; (ii) adoption by farm households of selected crop and livestock technologies and practices; (iii) crop and livestock productivity; (iv) commercialization of production—share of agricultural output sold by farm households; and (v) total household agricultural income per capita.

In the second-stage estimation, two different types of regressions were employed, depending on type of dependent variable in equation (2). We used probit for (i) demand for advisory services and (ii) adoption of selected crop and livestock technologies and practices; since the dependent variables here are dichotomous, i.e. take the value of one (representing demand or adoption) or zero (representing no demand or non-adoption). For the other outcome and impact indicators, we used the first-difference fixed-effect regression, since the dependent variables are continuous.

We compare the results from using this two-stage weighted regression method to those from using conventional instrumental variables (IV) methods, where equation 3 is first estimated by probit and then the predicted probability of being in the treatment group ($\widehat{NAADS}_j$) is used in the second-stage estimation of equation 2 as discussed above:

$$\Delta y_j = \hat{\alpha} + \hat{\boldsymbol{\beta}}'_{IV}\Delta \boldsymbol{x}_j + \hat{\delta}_{IV} \widehat{NAADS}_j + e_j \quad \text{.....(10)}$$

$$\Delta y_j = \hat{\alpha} + \hat{\boldsymbol{\beta}}'_{IV}\Delta \boldsymbol{x}_j + \hat{\delta}_{IV} \widehat{NAADS}_j + y_{jt0} + e_j \quad \text{.....(11)}$$

The main issue with the instrumental variables approach is finding appropriate instruments or predictors for the treatment or participation in the NAADS program (i.e. equation 3), since if weak instruments or predictors are used, the two-stage estimates could be more biased than the

simple OLS or probit estimates (Bound et al. 1995). This also relates to the identification of the second-stage equation (2) in the sense of excluding some of the explanatory variables used in estimating the first-stage equation from the second-stage equation (i.e. having $x \subset w$ or $x \neq w$), which we do. Due to the nonlinearity of the first-stage probit model, however, exclusion restrictions are not strictly necessary (Wilde 2000). Nevertheless, we still apply the exclusion restrictions to improve the identification of the model, and test the validity of the instruments using Hansen's (1982) chi-squared test of identification.

3.2.4. Estimating other effects

Distributional effects

To examine the distributional impacts of the NAADS program, we average the estimated ATT_j across several categories, including male versus female headed households, income terciles, regional administrations, and agro-ecological zones. The results of this exercise, however, needs to be interpreted with caution given that the sampling may not be representative of those categories, especially the regional and agro-ecological disaggregation, since the sub-counties were purposively selected. The results by gender and income group should be fine since households were randomly selected within the sub-counties.

Indirect or spillover effects

The NAADS program is by design expected to generate spillover effects, i.e. improve productivity and incomes farmers who are not members of a NAADS-participating farmer group. In the survey, respondents who were not members of any NAADS-participating farmer groups were asked whether they received advisory service from a NAADS community-based facilitator or whether they knew anyone who was a member of a NAADS-participating farmer group. A standard approach to measuring the spillover effects would be to create a dummy variable from the above information and include it in the regression model. However, such a variable perfectly predicts non-participation (i.e. $NAADS_j = \mathbf{0}$), which creates estimation problems. To overcome this problem, we estimate the impacts using alternative definitions of treatment (or of being a NAADS participant): the first one refers to membership in farmer group only, which aims at capturing the direct effects only; while the second definition includes indirect participants, which aims at capturing the total effects, i.e. direct and indirect effects. The difference between the *ATTs* associated with the estimators based on the alternative definitions of treatment is used as the estimate of the indirect effects of the NAADS program.

Lagged effects

Another advantage of using the two-stage regression approach for assessing the benefits is that we are able to estimate some of the lagged effects of the program, which is expected, since the benefits of the NAADS program, similar to those of any other public investment programs, often materialize with a lag. A variable capturing the number of years since the household joined the program (*YEAR*), which is measured by the year when the NAADS program was introduced in

the sub-county, is included in the regression model to capture the lagged effect. This is discussed further under the subsection on benefit-cost analysis.

3.2.5. Explanatory variables

Based on the conceptual framework presented in section 2, the choice of explanatory variables for the estimations was guided by the literature on agricultural household models (Singh et al. 1986; de Janvry et al. 1991), adoption of agricultural and agro-forestry technologies (Feder et al. 1985; Feder and Umali 1993; Pallanayak et al. 2003; Mercer 2004), willingness to pay for advisory services (Ajayi 2006; Dinar 1996; Holloway and Ehui 2001). We include factors that determine profitability of agricultural production such as: households' endowments of land, labor, and capital (which are important for labor, draft power, manure, credit, etc. where markets for such inputs do not function properly or exist); household's access to roads and other public goods and services (which affect the ability to purchase or hire inputs); land tenure status (which affect the future returns from current practices); and agro-ecological factors, population density and other village-level factors (which affect local comparative advantages).

Detailed description and measurement of the actual variables used will be discussed in the relevant sections. Generally, the variables used include: endowments of human capital (gender and age structure, size, and education); natural and physical capital (size of farm operated—cultivated and owned, value of agricultural productive assets); social capital (membership in organizations or networks); financial capital (livelihood and income strategies); and access to infrastructure and services (distance to nearest financial services, roads, and crop and livestock markets and services). Agroecology, biophysical and socio-cultural factors are captured by fixed-effect regional dummy variables representing the four administrative regions of Uganda—central, eastern, northern and western.

3.2.6. Interpretation of empirical results

As previously discussed, we utilize the different methods in order to provide a robust assessment of the impacts of the program and other factors. Nevertheless, we expect improvement in the estimates going from the simple DID method to the PSM and 2SWR methods. For the regression methods, we expect better estimates when the specific features of the panel data are exploited (i.e. initial values of the outcome or impact indicators are included in the model), compared to when they are not. Similarly for the matching methods, we expect better estimates when the matching takes account of differences in the covariates between the matched groups and with increasing number of neighbors used in the matching. However, because each method has its own advantages and disadvantages and no regression model is ever truly specified, we estimate the impact of the program or any factor on a specific outcome indicator as a range of values associated with the statistically significant coefficient of the relevant variable across various methods.

3.3. Returns to Investment: Benefit-Cost Analysis

Assessing the returns to investment in the NAADS program requires knowledge of the discounted benefits and costs. The basis for deriving the benefits was discussed in the preceding section. What are the costs?

3.3.1. Estimating the costs

Estimating the costs of the NAADS program is straightforward, and involves the costs associated with implementing the program so far. The costs are categorized into: farmer institution development; advisory and information services to farmers; enterprise and technology development and promotion; service provider capacity development; planning, monitoring and quality assurance; and program management and coordination.[10] We also impute and include the opportunity cost of the Community-Based Facilitators (CBFs), based on the amount of time spent in the delivering services. The cost associated with CBFs in time *t* ($C_{CBF,t}$) is imputed as follows:

$$C_{CBF,t} = EXT_{CBF,t} * \boldsymbol{h}_t * w_t * n_t \qquad \text{.....(12)}$$

Where EXT_{CBF} is the average number of CBF visits received by a farmer in a year (obtained from the survey data), *h* is the average number of hours spent by a CBF in a farmer visitation (this is assumed), *w* is the average hourly rate (based on the average labor rate per manday), and *n* is the number of farmers visited by a CBF.

3.3.2. Benefit-cost analysis

The standard technique for assessing the merits of public investment projects is cost-benefit analysis (CBA) by calculating the net present value (NPV) over the time horizon or life span of the program, *T*, within which the total costs of the program (*C*) are incurred and benefits ($ATT=\sum_j ATT_j$) accrue, according to (Dasgupta and Pierce 1972):

$$NPV = \sum_{t=0}^{T} \frac{ATT_t - C_t}{(1+r)^t}$$

Where *r* is the discount rate to capture the relative importance of the program's net benefits to different members of society, including those who have not yet been born. We use an 8.5 percent discount rate to be consistent with the rate used in appraising its public investment projects. As with any public investment program, the effect of NAADS is expected to materialize with a lag. Several studies have shown that the effect of agricultural extension last for up to 15 years

[10] Note that public investment projects can impact the environment or have indirect negative impacts on society, the cost of which needs to be taken into consideration. In the NAADS program, a typical example of possible negative impacts could be from the development of fish ponds, which may become breeding grounds for human disease vectors and parasites (e.g. mosquitoes), thereby reducing productivity, raising health cost, and reducing welfare in general. Such possible indirect costs are not dealt with here as we have no information on them.

(Rosegrant and Evenson 1995; Evenson et al. 1999; Alston et al. 2000; Fan et al. 2000; Huffman and Evenson 2006). Typically, we will expect the distribution of benefits over time to resemble the plots in Figure 5, which also shows the distribution of the total benefits ATT_{t1}^{total} for two different sub-counties (SC1 and SC2) where the program was implemented at different starting points in time.

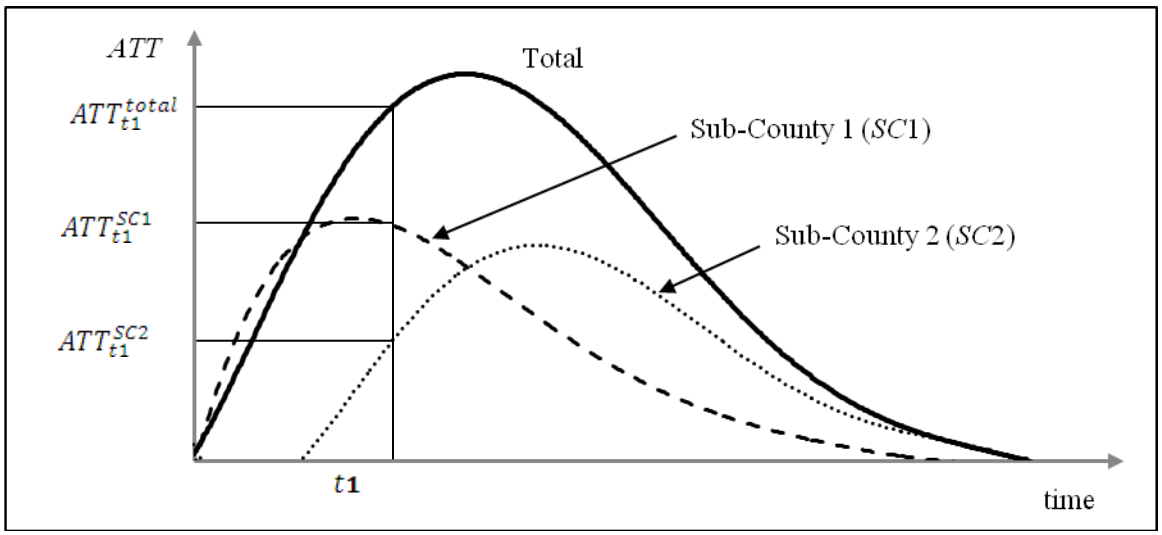


Figure 5. Distribution of benefits (*ATT*) over time and across geographic areas

Estimating the lag effects requires data over a long period of time, which is especially critical if we are to estimate turning point(s) in the benefit curve. This can be done by including squared and other higher-order terms of the time when the program was introduced into the sub-county in the regression analysis. Unfortunately, the data at hand covers only two or three years, which is limited for such an exercise. Based on the estimated coefficient associated with the time variable included the regression model, the estimated benefits are plotted against the year when the NAADS program was introduced into the sub-county to estimate the distribution of benefits over time or up to a specific point in time.[11]

As depicted in Figure 5, the *NPV* can be calculated for the entire program or for particular geographic areas (or sub-counties), assuming that the cost and benefits can be isolated for those geographic areas. Given that the survey data that are used in estimating the benefits are only representative of the sub-counties that were surveyed, rather than of the districts or at national level, we choose the latter option and calculate the *NPV* or benefit-cost ratio for the sub-counties in which the surveys were carried out.

[11] A similar plot of the benefits across different income groups can be generated to assess the income distribution of the NAADS program.

4. FARMER INSTITUTIONAL DEVELOPMENT AND DELIVERY OF ADVISORY SERVICES

4.1. Incidence of Rural Public Services on Farming Households

In general, availability of various services has improved over time, in terms of physical infrastructure based on secondary data obtained from the sub-county offices (Table 2) as well as farmers' own perceptions of their access to various services based on data from the farmer group surveys (Table 3).

All sub-counties

As Table 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 km in 2001 to 128 km in 2007. 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 others 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 services (education, health), water supply, and seasonal roads, averaging up to 3 km from their residence. This was followed by access to crop output markets and livestock slaughter houses, which averaged 7 km from their residence. Access to financial services (bank or microfinance institution), crop input markets, other livestock services and agricultural extension were reported to be the worst, averaging more than 10 km from their residence.

NAADS versus non-NAADS sub-counties

Comparing availability of services or access to services in NAADS versus non-NAADS sub-counties, Tables 2 and 3 show that availability and access were mixed, although they were better with many services in the NAADS sub-counties than in the non-NAADS sub-counties.

For example, roads were about 65 percent longer in NAADS sub-counties compared to non-NAADS sub-counties. Also, the number of primary schools, health centers, input supply shops, NGOs, and extension officers were higher in NAADS sub-counties compared to non-NAADS sub-counties, ranging from 44 to 180 percentage differences. Only recently in 2007 were the number of health centers, input supply shops and number of NGOs higher in non-NAADS versus NAADS sub-counties (Table 2). Many of the differences between NAADS and non-NAADS sub-counties based on secondary data are consistent with the differences based on farmers' own perception of their access to various services (Table 3). However, farmers in non-NAADS sub-counties reported better access to crop input markets, livestock slaughter houses, primary schools, public health center and water supply than those in NAADS sub-counties.

Table 2. Availability of services by NAADS and non-NAADS sub-county, 2001 to 2007

	2001				2004				2007			
	non-NAADS		NAADS		non-NAADS		NAADS		non-NAADS		NAADS	
	Mean	Standard error	Mean	Standard error	Mean	Standard error	Mean	Standard error	Mean	Standard error	Mean	Standard error
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
Murram/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
NGOs	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 sub-county offices.

Table 3. Farmers' perception of distance (km) to nearest infrastructure or service by NAADS and non-NAADS sub-county, 2004 and 2007

	2004				2007			
	Non-NAADS		NAADS		Non-NAADS		NAADS	
	Mean	Standard error	Mean	Standard error	Mean	Standard error	Mean	Standard error
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 slaughter house	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-IFPRI 2007 farmer group survey.

4.2. Farmer Institutional Development and Empowerment

Achieving the NAADS objective of establishing an effective and sustainable demand driven agricultural advisory service depends on how well NAADS-participating farmer groups and individual farmers are empowered to demand and control the delivery of those services. In the NAADS process, farmer group development activities begin 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 mentored through capacity development in several areas, including group dynamics, enterprise selection, and monitoring and evaluation. The trained groups that subscribe to the NAADS principles become "enterprise or commodity groups" (based on agricultural or related income generating ventures) and register with the sub-county office to fully participate in NAADS-related activities and benefit from NAADS guidance. During this process, NGOs and the Community Development Officers play leading roles. We now analyze several indicators of capacity development of farmer institutions, participation of members in group activities, and perception of farmer empowerment based on data from the farmer group surveys.

4.2.1. Farmer institution capacity development

Farmer groups were asked in the survey to reveal the areas they had received any form of training or capacity strengthening activities including: rights and responsibilities; group initiation, growth and development; leadership skills and development; developing constitution or bye-laws; 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 inter-group farmer association. Table 4 shows the proportion of farmer groups that received training on the above, as well as hypothesis tests of differences between non-NAADS and NAADS cohorts.

The most common areas that farmer groups reported they had received training included development of group constitution and bye-laws, leadership skills, growth and development, planning, record keeping, and savings mobilization. More than 70 percent of the groups in NAADS sub-counties reported this. Accessing credit and inter-group relations were the least common areas of training, with less than 60 percent of the groups in NAADS sub-counties reporting any training activity. Interestingly, farmer groups in the non-NAADS sub-counties 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 sub-counties reported having received training in any of the areas, compared to their counterparts in the intermediate or late NAADS sub-counties, which is expected given that it takes time to get things going. This reinforced by the significant differences in the proportions of groups in NAADS and non-NAADS sub-counties that reported they had received any training. This suggests that the NAADS program is gradually helping to strengthen the human resource skills and institutional capacity of farmers to potentially improve natural resource management, productivity, marketing, etc.

Table 4. 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-*t* tests: Non-NAADS vs.			
	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 constitution or bye-laws	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 NRM	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 consideration	0.65	0.07	0.60	0.08	0.33	0.33	0.62	0.05	0.45	0.08	**			**
HIV/AIDS consideration	0.71	0.07	0.51	0.09	0.33	0.33	0.62	0.05	0.45	0.08	**			*
Record keeping	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	***			*
Inter-group farmer associations	0.57	0.07	0.34	0.08	0.33	0.33	0.47	0.05	0.28	0.07	***			**

Notes: n is number of observations. SE is standard error. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.
Source: NAADS-IFPRI 2007 farmer group survey.

4.2.2. Participation in group activities

First, we analyze participation of individual farmers in their respective farmer group activities including meetings, enterprise selection, TDS establishment, and demonstrations. Then, we analyze key factors affecting group development and participation, including income and assets, gender, membership fees, etc. As done with in preceding discussion, the analysis here uses data from the farmer group surveys to compare means and variances of selected indicators across NAADS-participating groups and NAADS-non-participating groups. Among the NAADS-participating groups, the indicators are also compared across early, intermediate and late NAADS strata. Detail results are reported in Table 5.

Participation in meetings

We find that participation of farmers in meetings was very high among all farmer groups, i.e. in both NAADS participating and non-participating groups. However, we find participation in meetings to be relatively higher among the NAADS non-participating groups. Since NAADS participating groups are formed from existing groups in the communities, this result is somewhat surprising. Nevertheless, it suggests that efforts to build farmers' capacity to demand advisory services are more likely to yield larger payoffs when those efforts are targeted toward existing farmer groups with similar or complementary goals and objectives. Thus, the strategy of NAADS to collaborate with other organizations that have experience in farmer institutional development is in the right direction. NAADS can focus effort on developing strategies for group viability and sustainability.

Participation in enterprise selection, demonstrations and training

The information here was restricted to NAADS-participating groups only, as it was not relevant for the others. We find increasing performance of participation with period of entry into the program with regard to enterprise selection, which is expected since most of the participating groups in the early NAADS sub-counties would have already selected most of the enterprises of their choice, reducing their zeal to further participate in this activity. Newer groups, on the other hand, have more interest in this activity, as it is also one of the initial decisions to be made in order to benefit from NAADS support. These results suggest a shift in interest among the older NAADS groups from basic agronomic and production practices to participate in higher value-chain activities such as marketing and value addition. Thus, operationalization of NAADS' strategy regarding graduation of activities upwards along the entire value chain is critical.

Participation in selection of service providers and monitoring and evaluation

Participation in selection of service providers and monitoring and evaluation was relatively weak across the board, with more than 65 percent of the groups reporting that members do not participate in these activities (Table 5). Participation was only slightly higher among the older groups (i.e. in early NAADS sub-counties) than among newer groups (i.e. in intermediate NAADS districts). This suggests that farmers are not as empowered as expected to demand and monitor delivery of advisory services, and so more effort is needed.

Table 5. Perception of participation of members since 2004 in group activities by NAADS cohorts and non-NAADS (proportion of groups reporting)

	Early NAADS (n=49)		Intermediate NAADS (n=35)		Late NAADS (n=6)		All NAADS (n=90)		Non-NAADS (n=46)		Paired student-*t* tests: Early-NAADS vs.		
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Intermediate NAADS	Late NAADS	Non-NAADS
Meeting													
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.			

Notes: n is number of observations. SE is standard error. n.a. means not applicable. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.

Source: NAADS-IFPRI 2007 farmer group survey.

Factors affecting group participation

Here we consider economic and socio-cultural factors, including income, gender, education, religion, and membership fees (Table 6). The level of income, gender, education, and religion of farmers were not considered important factors in determining group membership, as less than 15 percent of the groups in any stratum reported that they were important factors. There were some significant differences across some of the stratum, however, particularly between NAADS participating and non-participating groups, where a greater proportion of the non-participating groups reported that education and gender were important factors. The above results also imply that wealth status is not a hindrance to membership in any group, whether NAADS or not, which is important if the NAADS program is to reach poor farmers. Payment of membership fees, age and location, however, were considered to be important factors in determining membership. Regarding membership fees, nearly all the groups (at least 91 percent) reported that it was important, probably because it is the main source of the group's financial resources, and in the case of NAADS participating groups, for establishing the co-payment requirement to attract NAADS grants. This could be a hindrance to participation, as the membership fees reported (Table 6) may not be affordable to all farmers, especially poorer farmers, which somewhat negates the earlier finding that wealth status is not a hindrance to membership in any group.

4.2.3. Farmer empowerment

Farmer groups were asked to express their opinion according to change since 2004 in the level of ease (or difficulty) in expressing their views to sub-county authorities, including farmers forum, technical public officers, and political leaders (Table 7). Only a few of the groups (less than 20 percent) reported that they found it more difficult (reduced empowerment) to express views to various authorities. The largest proportion groups reporting an increase in the level of empowerment to express views to the authorities was among those in the early NAADS sub-counties, followed by those in the intermediate NAADS sub-counties, and then those in the non-NAADS sub-counties. About one-third of the groups on average reported no change in their level of empowerment. Comparing empowerment toward the different authorities, the groups felt more empowered since 2004 to express their views toward technical public officers, followed by the farmers' forum and then political leaders (Table 7). This is encouraging since technical public officers are better placed than the others to address farmers' agricultural production problems or concerns.

Farmer groups were also asked to express their opinion on the change since 2004 in the response by sub-county authorities towards their requests or complaints (i.e. increased response, no change in response, or reduced response) (Table 8). The ratings here were less favorable. The majority of the groups indicated that there was reduction or no change in the response rate of authorities to their requests, with the response by technical public officers receiving the worst rating. These results suggest a weakening of advisory services as the NAADS program rolls out to more districts and sub-counties without complementary increase in resources to maintain or increase advisory services to those already participating in the program as well as taking on new farmers.

Table 6. Group membership requirements by NAADS cohorts and non-NAADS

	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 vs:			
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Early NAADS	Interm NAADS	Late NAADS	All NAADS
Whether item is requirement 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				

Notes: n is number of observations. SE is standard error. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.
Source: NAADS-IFPRI 2007 farmer group survey.

Table 7. Perception of change since 2004 in empowerment towards officials by NAADS cohorts and non-NAADS (proportion of groups reporting)

	Early NAADS (n=50)		Intermediate NAADS (n=36)		Late NAADS (n=6)		All NAADS (n=92)		Non-NAADS (n=54)		Paired student-*t* tests: Non-NAADS vs:			
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Early NAADS	Interm. NAADS	Late NAADS	All NAADS
Sub-county 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.				
Sub-county 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				

Notes: n is number of observations. SE is standard error. n.a. means not applicable. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.
Source: NAADS-IFPRI 2007 farmer group survey.

Table 8. Perception of change since 2004 in response by officials towards group requests by NAADS cohorts and non-NAADS (proportion of groups reporting)

	Early NAADS (n=50)		Intermediate NAADS (n=36)		Late NAADS (n=6)		All NAADS (n=92)		Non-NAADS (n=54)		Paired student-*t* tests: Non-NAADS vs:			
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Early NAADS	Interm. NAADS	Late NAADS	All NAADS
Sub-county 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.				
Sub-county 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				

Notes: n is number of observations. SE is standard error. n.a. means not applicable. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.
Source: NAADS-IFPRI 2007 farmer group survey.

4.3. Supply of Advisory Services

As NAADS is enterprise-based, one of the first activities of the farmer group is to prioritize their enterprises on which advisory services would be demanded. The enterprise can be crop, livestock, fisheries, or beekeeping or a mix of them. Each group prioritizes three enterprises—clearly identifying associated technological and advisory service constraints. The information is then forwarded to the sub-county farmer forum where three specific enterprises are selected to be supported under NAADS program in a sub county. Several issues have emerged due to the small number of enterprises that can be selected in any sub-county. For example, ITAD (2008) find evidence of political interference in the process where, in some sub-counties, some enterprises were believed to be selected to meet politicians' demands rather than those of farmers. With a limit of three enterprises per sub-county, however, it is inevitable that many farmers will find their preferred enterprise not being included and they may be compelled to opt out of the program (see ITAD 2008 for further discussion of some of the issues).

Following selection of the three enterprises, NAADS provides technologies for demonstration on a member of a farmer group's (or host farmers) field—technology development site (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 were given, based on secondary data provided by officials of the sub-counties where farmer group and household surveys were conducted.

Crops

In all, about 36 enterprises (29 crop and 7 non-crop enterprises) were promoted, in terms of the type of TDSs that had been established and the type of demonstrations that were held. As expected, not all enterprises were promoted or demanded in every sub-county. The major crops promoted were banana and groundnuts, followed by rice, vanilla and maize (Figure 6). It is important to also look at how long a TDS has been in existence, since we will expect greater response to adoption of enterprises that are promoted widely (i.e. in several places) as well as been promoted over a long period of time. For example, banana has been promoted in more than 10 sub-counties (or more than 35 percent of the total NAADS sub-counties surveyed) since 2002 and reached 23 sub-counties (or 60 percent) by 2007. Comparing rice and groundnuts, although they were both promoted in 16 sub-counties (or 43 percent of the total number of sub-counties) by 2007, rice was not promoted at all in 2001 and 2002, and in less than 6 sub-counties (or 18 percent of the total) until 2005. Groundnuts on the other hand have been promoted since 2001 and in more than 10 sub-counties 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 7), groundnuts and rice are the most favored crop enterprises, with 540 and 535 TDSs being established by 2007, respectively. In terms of the number of registered NAADS farmer groups directly benefiting from the TDSs and demonstrations, banana, groundnuts and rice were the most favored crop enterprises, with 1512, 1247 and 1132 farmer groups benefiting by 2007, respectively (Figure 7). Together, these results suggest that banana and groundnuts are the most widely promoted crop enterprises.

Livestock and other enterprises

Regarding livestock and other agricultural enterprises, the major ones promoted in terms of the number of sub-counties where they were promoted were goats (in 35 sub-counties by 2007), poultry (27), beekeeping (24), cattle (23), and piggery (18) (Figure 6). In terms of the number of TDSs established, goats, beekeeping and poultry were the most favored, having 441, 458 and 478 TDSs established, respectively, by 2007. Regarding the number of farmer groups benefiting, goats and poultry were the most favored with 2144 and 2133 farmer groups, respectively, benefiting under each enterprise by 2007. Together, these results suggest that goats and poultry are the most widely promoted livestock enterprises.

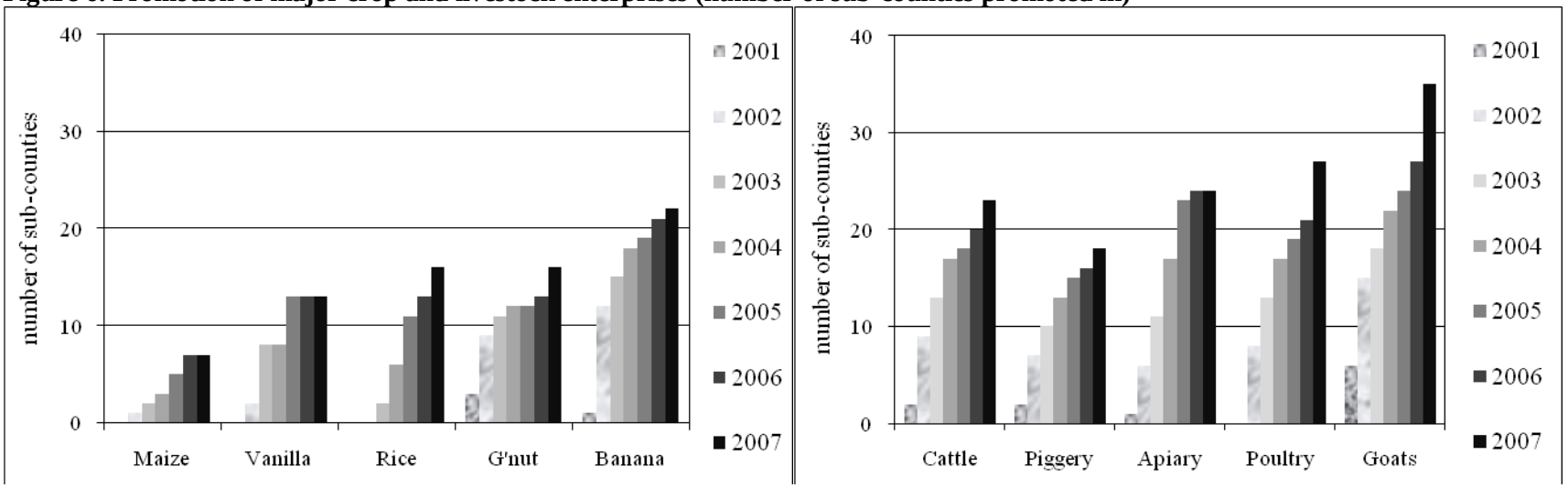
Comparing all the enterprises by the various categories (i.e. in terms of number of sub-counties, number of TDSs and number of groups benefiting), the above results suggest that livestock were most widely promoted of the agricultural enterprises.

4.4. 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. NAADS undertakes quality assurance through technical auditing, which is the responsibility of district-based subject matter specialists, who also supervises 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 trainings they had received from the private service providers as well as rate the service providers on their methods used and performance.

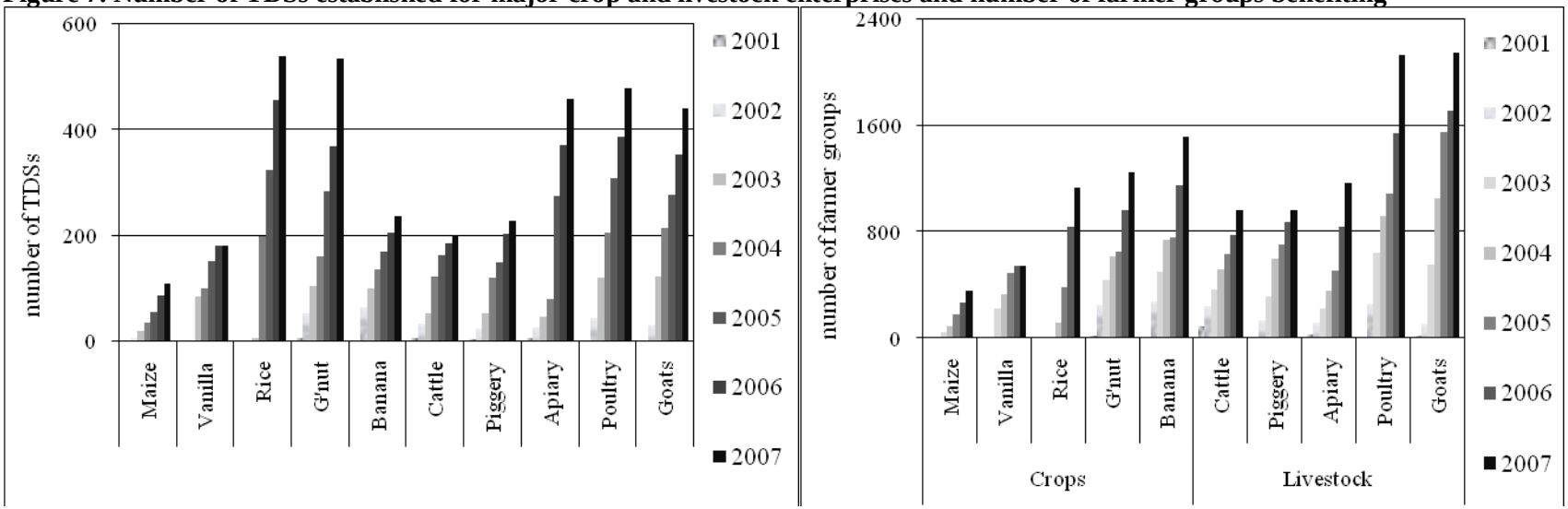
The results in Table 9 show that the majority (about 90 percent) of the farmers found the various areas of training or capacity strengthening activities to be very useful or useful; with more groups in the early NAADS sub-counties finding them very useful or useful than those in intermediate NAADS sub-counties. NAADS service providers, compared to others, were rated very high on their methods and performance suggesting that the NAADS program is helping to strengthen the human resource skills and institutional capacity of farmers to potentially improve natural resource management, productivity, marketing, etc.

Figure 6. Promotion of major crop and livestock enterprises (number of sub-counties promoted in)



Source: NAADS-IFPRI 2007 sub-county survey.

Figure 7. Number of TDSs established for major crop and livestock enterprises and number of farmer groups benefiting



Source: NAADS-IFPRI 2007 sub-county survey.

Table 9. Perception on usefulness of training received by NAADS cohorts and non-NAADS (proportion of groups reporting)

	Early NAADS (n=43)		Intermediate NAADS (n=28)		Late NAADS (n=2)		All NAADS (n=73)		Non- NAADS		Paired student-*t* tests: Early-NAADS vs:	
	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.		

Notes: n is number of observations. SE is standard error. n.a. means not applicable. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.
Source: NAADS-IFPRI 2007 farmer group survey.

5. OUTCOMES AND IMPACTS OF NAADS

This section focuses on the effect of participation in the NAADS program on several outcome and impact indicators, including the demand for advisory services, adoption of technologies, crop and livestock productivity, agricultural income, consumption expenditure, and welfare. Depending on the data that is available, the impact of NAADS on these indicators is estimated using the four different methods presented earlier: differences-in-difference method (i.e. estimate $\hat{\delta}_{DID}$); propensity score matching method (i.e. $\hat{\delta}_{PSM}$); instrumental variables regression method (i.e. $\hat{\delta}_{IV}$); and two-stage weighted regression method (i.e. $\hat{\delta}_{2SWR}$). The effects of other influential factors on realizing the various outcomes and impacts are also quantified and analyzed using the two-stage weighted and instrumental variables regression methods. We use the panel data from the 2004 and 2007 household surveys for the analyses.

Before getting to the estimation, we first need to establish who is a NAADS participant. Although the NAADS program is a public investment intervention, farmers have to decide whether to participate or not to participate in the program. When a farmer decides to participate, he or she has to do so through membership of a NAADS-participating farmer group. Then, together with the members of the group, as well as with members of other NAADS-participating groups in the sub-county, they request for specific technologies and advisory services associated with their preferred enterprises and also obtain grants to support acquisition and development of those technologies, as discussed earlier. The grant is initially used to finance the establishment of a TDS, the proceeds of which becomes a revolving fund for members. Thus, the direct benefit or impact of the program is via farmers' access to this grant or revolving fund. However, the NAADS TDSs and community-based facilitators are accessible to all farmers in sub-county as sources of knowledge, irrespective of a farmer's membership in a NAADS-participating or not. This is the channel through which the indirect benefit or impact of the program is manifested.

To capture the direct impacts as well as the indirect or spillover effects of the program, we used two definitions of participation in the NAADS program. The first one refers to membership in a NAADS-participating farmer group only (*NAADS_direct*), which aims at capturing the direct effects; while the second definition includes indirect participants (*NAADS_total*), which aims at capturing the total effects. The difference between the estimated *ATTs* associated with the two definitions of participation in NAADS is used as a measure of the indirect effect of the program. Given the large amount of output associated with the different definitions, however, we only report detailed results for the total effect, noting what the direct and indirect effects are where relevant. Note that the NAADS program was not implemented everywhere at the same time, but rather rolled out to a few districts and sub-counties each year. Therefore, we do not observe the participation decision of farmers in areas where the program was not being implemented at the time of the surveys. This implies that the participation decision variable (*NAADS_direct* or *NAADS_total*) is truncated when the considering the data and observations from the non-NAADS sub-counties. We deal with this problem by excluding from the analyses the data on the non-NAADS sub-counties. And after dropping observations with missing information on relevant variables, as well as those with outliers, 535 panel observations (or 1070 total observations) remained for the analyses. About 41 and 31 percent of the farm-households were classified as direct and indirect participants, respectively. To assess some of the lagged effects of

the program, we include a dummy variable representing the year when the NAADS program was introduced in the sub-county (*NAADS_years*); representing 2001/02 (about 60 percent of the sub-counties), 2002/03 (25 percent), and after 2003 (15 percent). Detail description and summary statistics associated with the NAADS participation variables are given in Table 10.

Table 10. Description and summary statistics of NAADS participation variables

NAADS indicator		Mean	Standard Error
NAADS_direct	Dummy variable for whether household is a member of a NAADS-participating farmer group: 0=no; 1=yes	0.490	0.023
NAADS_total	Dummy variable for whether household is a member of a NAADS-participating farmer group or accessed or received NAADS-related advisory services: 0=no; 1=yes	0.717	0.021
NAADS_years	Dummy variable for year NAADS implemented in sub-county (base is after 2003)		
NAADS_year02/03	If 2002/2003	0.252	0.018
NAADS_year01/02	If 2001/2002	0.604	0.023

Source: NAADS-IFPRI 2004 and 2007 household surveys.

Detailed description and measurement of all other variables (dependent and independent) used in the analyses are given in Table 11. This is presented first for selected outcome and impact indicators of the NAADS program including the demand for advisory services, adoption of technologies and practices, crop and livestock productivity, agricultural income, marketing, and welfare (consumption expenditure and food and nutrition security). This is followed by the explanatory variables used in the regressions: demographics (gender, age, education and size of the household); income sources and physical capital endowment (size of farm operated—cultivated and owned, value of agricultural productive assets); social capital (membership in organizations or networks); access to infrastructure and services (distance to nearest financial services, roads, and crop and livestock markets and services). Agroecology, biophysical and socio-cultural factors are captured by fixed-effect regional dummy variables representing the four administrative regions of Uganda (Central, Eastern, Northern and Western).

Table 11. Description of variables and summary statistics for NAADS participants and non- participants

Variable name	Variable description	NAADS non-participants				NAADS participants			
		2004		2007		2004		2007	
		Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
Dependent variables (Outcome and Impact Indicators)									
Demand for advisory services									
Crop varieties	Dummy variable for whether household requested for improved crop varieties used: 0=no; 1=yes	na	na	0.352	0.029	na	na	0.423	0.028
Crop management	Dummy variable for whether household requested for improved crop management practices used: 0=no; 1=yes	na	na	0.151	0.025	na	na	0.245	0.026
Soil conservation	Dummy variable for whether household requested for soil conservation technologies used: 0=no; 1=yes	na	na	0.089	0.023	na	na	0.189	0.026
Soil fertility	Dummy variable for whether household requested for soil fertility technologies used: 0=no; 1=yes	na	na	0.166	0.028	na	na	0.226	0.028
Agroforestry	Dummy variable for whether household requested for agroforestry technologies used: 0=no; 1=yes	na	na	0.066	0.026	na	na	0.177	0.036
Livestock breeds	Dummy variable for whether household requested for improved livestock breeds used: 0=no; 1=yes	na	na	0.279	0.040	na	na	0.333	0.038
Marketing	Dummy variable for whether household requested for marketing information used: 0=no; 1=yes	na	na	0.143	0.097	na	na	0.290	0.058
Post harvest	Dummy variable for whether household requested for post-harvest technologies used: 0=no; 1=yes	na	na	0.373	0.056	na	na	0.358	0.042
Adoption of new enterprises									
New crop enterprises	Dummy variable for whether household adopted new enterprises: 0=no; 1=yes	na	na	0.300	0.024	na	na	0.250	0.048
Technology adoption									
Improved seeds	Dummy variable for whether household used improved crop varieties or not: 0=no; 1=yes	0.298	0.029	0.496	0.031	0.523	0.029	0.740	0.025
Spacing	Dummy variable for whether household	0.439	0.031	0.438	0.031	0.674	0.027	0.724	0.025

	used recommend spacing/planting practices or not: 0=no; 1=yes								
Inorganic fertilizer	Dummy variable for whether household used inorganic fertilizer or not: 0=no; 1=yes	0.102	0.019	0.062	0.015	0.138	0.020	0.083	0.016
Pesticides	Dummy variable for whether household used pesticides or not: 0=no; 1=yes	0.157	0.023	0.205	0.025	0.369	0.028	0.266	0.025
Improved breeds	Dummy variable for whether household used improved livestock breeds or not: 0=no; 1=yes	0.140	0.027	0.254	0.032	0.211	0.027	0.360	0.031
Production									
Crop output	Value of total crop output per acre ('000 UGX, 2000 value)	250.255	25.319	355.707	46.454	278.047	19.336	422.347	50.913
Livestock output	Value of total livestock output per TLU ('000 UGX, 2000 value)	193.552	35.741	544.673	73.526	275.539	46.675	494.285	58.898
Agricultural income	Value of total agricultural output per capita ('000 UGX, 2000 value)	185.617	24.820	246.230	37.606	195.942	22.980	314.582	36.287
Marketing									
Marketed share_total	Proportion of total agricultural (crop, livestock, apiary, aquaculture) output sold	32.477	1.788	17.458	1.302	34.040	1.428	17.402	1.211
Marketed share_crop	Proportion of total crop output sold	29.150	1.549	24.966	1.619	37.066	1.414	28.274	1.477
Marketed share_lvst	Proportion of total livestock output sold	28.296	2.920	6.635	1.146	30.682	2.537	4.078	0.787
Welfare									
Consumption	Value of total consumption expenditure per capita ('000 UGX, 2000 value)	na	na	182.325	18.646	na	na	170.907	12.378
Food security	Perception of change in access to adequate food (%) [a]								
	Improved	0.360		0.380		0.440		0.540	
	No change	0.160		0.310		0.140		0.240	
	Worsened	0.480		0.310		0.240		0.220	
Human nutrition	Perception of change in nutritional quality of food (%) [a]								
	Improved	0.370		0.270		0.470		0.410	
	No change	0.260		0.510		0.250		0.470	
	Worsened	0.360		0.220		0.280		0.120	
Overall wellbeing	Perception of change in overall wellbeing (%) [a]								
	Improved	na		0.440		na		0.560	
	No change	na		0.290		na		0.210	
	Worsened	na		0.270		na		0.230	

Exogenous variables

Human capital									
Gender of head	Dummy variable for gender of household head: 0=male; 1=female	0.168	0.024	0.242	0.028	0.150	0.020	0.182	0.024
Age of head	Age of household head (years)	43.402	0.929	45.688	0.961	44.559	0.777	46.747	0.863
Education	Dummy variable for education of household head (base is if no formal education)								
Primary	If attended or completed primary education	0.656	0.030	0.693	0.030	0.559	0.028	0.704	0.029
Post-primary	If attended of completed some post-primary education	0.184	0.025	0.126	0.022	0.320	0.027	0.209	0.026
Household size	Number of household members	6.439	0.209	6.610	0.211	6.961	0.183	7.751	0.246
Social Capital									
Membership in other organization	Dummy variable for membership of a household member in any socio-economic group: 0=no member; 1=member	0.480	0.032	0.342	0.031	0.765	0.024	0.846	0.023
Financial capital									
Income strategy	Dummy variable for primary source of income of household (base is crops)								
Livestock	If livestock is primary source	0.049	0.014	0.048	0.014	0.042	0.012	0.051	0.014
Other agriculture	If other agriculture is primary source	0.057	0.015	0.074	0.017	0.036	0.011	0.055	0.014
Non-farm	If non-farm is primary source	0.143	0.022	0.260	0.029	0.147	0.020	0.221	0.026
Physical capital									
Land owned	Total farmland area owned (acres)	2.267	0.503	2.392	0.964	2.074	0.592	2.115	0.644
Crop area	Total farmland area under cultivation (acres)	8.034	1.850	11.210	3.318	6.165	0.857	7.866	1.490
Productive assets	Value of total agricultural productive assets—equipment and livestock ('000 UGX, 2000 value)	207.612	51.090	293.935	56.796	162.690	32.079	230.604	28.440
Access to services	Average distance (km) to nearest:								
Credit	Bank or credit association	17.268	1.065	16.307	1.101	19.015	0.943	17.479	0.976
All-weather road	All-weather road	2.705	0.287	2.723	0.298	2.414	0.247	2.258	0.256
Markets	Crop or livestock market or services (input supply, veterinary, etc.)	7.859	0.363	7.711	0.376	8.853	0.427	8.945	0.453

Notes: [a] perception of change refers to change between 2000 and 2004 for the year 2004, and change between 2004 and 2007 for the year 2007.
Source: NAADS-IFPRI 2004 and 2007 household surveys.

5.1. Determinants of Participation in the NAADS Program

Using the data from the household survey, the decision to participate or not to participate in the NAADS program is analyzed by estimating equation (3) by probit using the initial or 2004 values of the variables included (Table 12). The results show that the longer the NAADS program has been in the sub-county the more likely farmers are to participate in the program. However, with NAADS being rolled out to more districts and sub-counties, the resources needed to cover the increasing population becomes severely compromised and limits the availability of grants (private-good nature of the program), which may stop some farmers from joining the program to begin with.

Table 12. Probit results of participation in the NAADS program

	Coefficient
NAADS_years (cf.: after 2003)	
NAADS_year02/03	0.860 ***
NAADS_year01/02	1.208 ***
Gender of head	0.090
Ln Age of head	0.221
Education (cf.: no formal education)	
Primary education	0.178
Post primary education	0.304
Ln Household size	0.213
Membership in other organizations	1.020 ***
Income strategy (cf.: crops)	
Livestock	-0.003
Other agriculture	-0.183
Non-farm	-0.086
Ln Land owned	0.102
Ln Crop area	0.039
Ln productive assets	0.071 **
Ln Distance to service:	
Credit	0.008
All-weather road	0.050
Markets	0.006
Region (cf.: Central)	
Eastern	-0.016
Northern	0.939 ***
Western	0.540 ***
Intercept	-3.249 ***
R-squared	0.226
Likelihood Ratio Test	139.940 ***

See Table 11 for detail description of variables. The explanatory variables are 2004 values. Ln means transformation by natural logarithm. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.

As expected, membership or participation in other organizations, which is a measure of social capital, is also strongly associated with greater likelihood of participation in the NAADS program. This is consistent with the NAADS approach in terms of targeting existing groups, to maximize the payoffs from efforts to build farmers' capacity to demand advisory services. The statistical insignificance of gender, age, education, and income source is consistent with the

earlier result on the perception of farmers that these factors are generally not important in determining group membership. This implies that the NAADS program is targeting all socio-economic groups. The value of productive assets, however, is a significant factor determining participation. With payment of membership fees being an important factor perceived by farmers as consideration for group membership (earlier result), the above finding is not surprising. It also reflects NAADS' strategy in targeting the economically-active poor (i.e. those with limited physical and financial assets, skills and knowledge), rather than destitute.

Looking at the regional disaggregation, farmers in the Northern Region were the most likely to participate in the program, followed by those in the Western Region, as compared to their counterparts in the Central and Eastern Regions.

Difference in characteristics between NAADS (treated) and non-NAADS (control) groups

The above probit results are used to estimate the propensity scores that are used to match NAADS participants (treatment) and non-participants (control) groups for the PSM method. The propensity scores are also used as the weights for the two-stage weighted regression (2SWR) method. This is based on rationale presented earlier for reducing the bias associated with observable differences between participants and non-participants that not only affect the participation decision but also outcomes of the program. The kernel matching method was used. Among the 535 households that formed the panel data, 53 households (50 participants and 3 non-participants) did not match and were dropped for the subsequent analyses. Table 13, which is based on the "balancing test" of Dehejia and Wahba (2002), shows the statistical difference between the NAADS-participating households (treated) and the non-participating households (control) for the matched and unmatched samples in the means of the variables used above, which are also the factors likely to affect the outcome and impact indicators of the program. Unlike the unmatched sample, where most of the observable characteristics are statistically different between the participants and non-participants, the matched participants and non-participants are comparable in the observable characteristics. The only exception is with access to credit and location in the intermediate NAADS sub-county and Northern region, although these are marginally significant (i.e. at 10 percent level only).

Since we have a panel data, it is important to consider that the above factors, which also are likely to affect the outcome and impact indicators of the program, may be changing over time differently across the matched participants and non-participants. The effects of the factors on the outcome and impact indicators of the program may also vary over time, and the change in the factors may be occurring independently of the effects of the program. Table 14 shows the statistical difference between the NAADS-participating households (treated) and the non-participating households (control) for the matched and unmatched samples in the means of the change between 2004 and 2007 in the same variables presented above. We see that change in many of the observable characteristics between the matched participants and non-participants of the NAADS program are statistically significant. Therefore, attributing the difference in the change in the value of program's outcome and impact indicators between the matched participants and non-participants, where the match is based on the initial values of the factors (or pre-treatment characteristics in general) only, may be misleading.

Table 13. Balancing test of differences in observable characteristics in 2004 between NAADS participants (treated) and non-participants (control)

Variable (2004 values)	Sample	Mean		Bias (%)	Reduction of bias (%)	t-test
		Treated	Control			
NAADS_years (cf.: after 2003)						
NAADS_year02/03	Unmatched	0.355	0.279	16.50		***
	Matched	0.284	0.227	12.40	24.60	*
NAADS_year01/02	Unmatched	0.548	0.488	12.00		*
	Matched	0.604	0.650	-9.20	23.40	
Gender of head	Unmatched	0.142	0.170	-7.90		
	Matched	0.150	0.167	-4.90	37.80	
Age of head	Unmatched	44.323	42.845	10.40		
	Matched	43.953	44.921	-6.80	34.50	
Education (cf.: no formal education)						
Primary education	Unmatched	0.595	0.662	-14.00		**
	Matched	0.616	0.643	-5.60	59.80	
Post primary education	Unmatched	0.284	0.170	27.30		***
	Matched	0.243	0.213	7.30	73.10	
Household size	Unmatched	6.869	6.498	11.20		*
	Matched	6.719	7.637	-27.70	-148.00	***
Membership in other organizations	Unmatched	0.730	0.312	91.90		***
	Matched	0.701	0.689	2.50	97.20	
Income strategy (cf.: crops)						
Livestock	Unmatched	0.043	0.050	-3.60		
	Matched	0.047	0.052	-2.20	38.60	
Other agriculture	Unmatched	0.031	0.069	-17.60		***
	Matched	0.041	0.040	0.40	97.80	
Non-farm	Unmatched	0.139	0.158	-5.10		
	Matched	0.152	0.158	-1.70	67.50	
Land owned	Unmatched	2.133	2.337	-2.20		
	Matched	1.993	2.059	-0.70	67.40	
Crop area	Unmatched	0.980	1.180	-6.40		
	Matched	0.890	1.028	-4.40	31.40	
Productive assets	Unmatched	210.000	160.000	7.20		
	Matched	200.000	180.000	2.50	65.20	
Distance to service:						
Credit	Unmatched	18.637	17.606	6.30		
	Matched	16.375	14.409	11.90	-90.60	*
All-weather road	Unmatched	2.439	2.502	-1.50		
	Matched	2.669	2.527	3.40	-125.10	
Markets	Unmatched	8.682	7.082	26.00		***
	Matched	8.197	7.533	10.80	58.50	
Region (cf.: Central)						
Eastern	Unmatched	0.173	0.309	-32.20		***
	Matched	0.211	0.231	-4.60	85.60	
Northern	Unmatched	0.245	0.091	42.00		***
	Matched	0.135	0.094	11.10	73.70	*
Western	Unmatched	0.424	0.379	9.30		
	Matched	0.463	0.494	-6.30	32.80	

See Table 11 for detail description of variables. The variables are 2004 or initial values. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively, of the difference in the means between NAADS participants (treated) and non-participants (control).

Table 14. Balancing test of differences between NAADS participants (treated) and non-participants (control) in the change between 2004 and 2007 in observable characteristics

Variable	Sample	Mean		Bias (%)	Reduction of bias (%)	t-test
		Treated	Control			
Gender of head	Unmatched	0.026	0.091	-20.70		***
	Matched	0.024	0.119	-29.90	-44.40	***
Age of head	Unmatched	1.418	3.713	-23.10		***
	Matched	1.561	3.885	-23.40	-1.30	***
Education (cf.: no change)						
Reduction	Unmatched	0.112	0.114	-0.70		
	Matched	0.110	0.129	-6.00	-818.60	
Improvement	Unmatched	0.128	0.081	15.70		
	Matched	0.120	0.026	30.80	-96.70	***
Household size	Unmatched	0.654	0.244	13.20		
	Matched	0.605	-0.324	29.90	-126.50	***
Membership in other organizations	Unmatched	-0.019	0.045	-10.90		
	Matched	0.009	-0.307	54.00	-394.20	***
Income strategy (cf.: no change)						
To crops	Unmatched	0.082	0.135	-17.10		*
	Matched	0.101	0.095	1.70	89.80	
To livestock	Unmatched	0.042	0.043	-0.40		
	Matched	0.045	0.069	-12.30	-3039.30	
To other agriculture	Unmatched	0.059	0.049	4.20		
	Matched	0.056	0.117	-27.00	-545.40	***
To non-farm	Unmatched	0.171	0.239	-16.90		*
	Matched	0.172	0.267	-23.60	-39.30	***
Land owned	Unmatched	0.067	-0.157	1.50		
	Matched	-0.212	-0.708	3.40	-121.90	
Crop area	Unmatched	0.128	-0.066	4.70		
	Matched	0.079	0.321	-5.90	-24.50	
Productive assets	Unmatched	73.385	140.000	-12.80		
	Matched	81.066	69.431	2.30	82.00	
Distance to service:						
Credit	Unmatched	-1.305	-1.036	-4.00		
	Matched	-1.093	-0.933	-2.40	40.30	
All-weather road	Unmatched	0.005	-0.012	3.20		
	Matched	-0.025	-0.006	-3.50	-8.70	
Markets	Unmatched	-0.077	-0.095	0.90		
	Matched	-0.125	-0.095	-1.50	-64.00	

See Table 11 for detail description of variables. The variables are change between 2004 and 2007. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively, of the difference in the means between NAADS participants (treated) and non-participants (control).

This is the underlying rationale for the two-stage weighted regression method, where we use the propensity scores discussed above as weights. The regression addresses the effect of change in the factors over time, while the weights removes bias due to any correlation between the program and the factors; making the estimator doubly-robust (Imbens and Wooldridge 2008).

5.2. Demand for Advisory Services

To examine the demand for advisory services, farmers were asked in the household survey to report the improved technologies and practices that they adopted between 2004 and 2007, and then to report whether they had specifically asked for (or demanded) those improved technologies or practices. This question was only asked in the 2007 survey and so we do not have observations to undertake a panel data analysis. As presented in the methodology section, we used the conventional instrumental variables (IV) approach as well as the two-stage weighted regression (2SWR) approach to assess the impact of the NAADS program, as well as of other factors presented in the conceptual framework, on farmers' demand for selected improved technologies and practices, including crop improved varieties, crop improved management practices,[12] soil fertility improved management practices, agroforestry, livestock improved breeds, post-harvest handling technologies, and marketing and agro-processing improved technologies and practices. Although we asked farmers to report on several technologies and practices that they used, these were the technologies with relatively high frequency of demand to warrant meaningful econometric estimation. The estimation is based on the matched sample.

The conceptual factors that affect demand for advisory services was presented in the conceptual framework and the empirical approach and so it will not be repeated here. However, the effects of the variables used here on demand for advisory services may be different from their effects reported in previous adoption studies (e.g.: Pallanayak et al. 2003; Mercer 2004; Ajayi 2006; Dinar 1996; Holloway and Ehui 2001), since such studies do not differentiate supplied and demanded agricultural technologies. For example, Frisvold et al. (2001) note that the stock of extension services available to farmers affects demand for advisory services, and they estimated the demand for extension services at county level in Arizona using a system of demand and supply equations. We do not estimate a system of demand and supply equations in this study since we use household level data and we do not have adequate information on the supply side to estimate a supply equation.

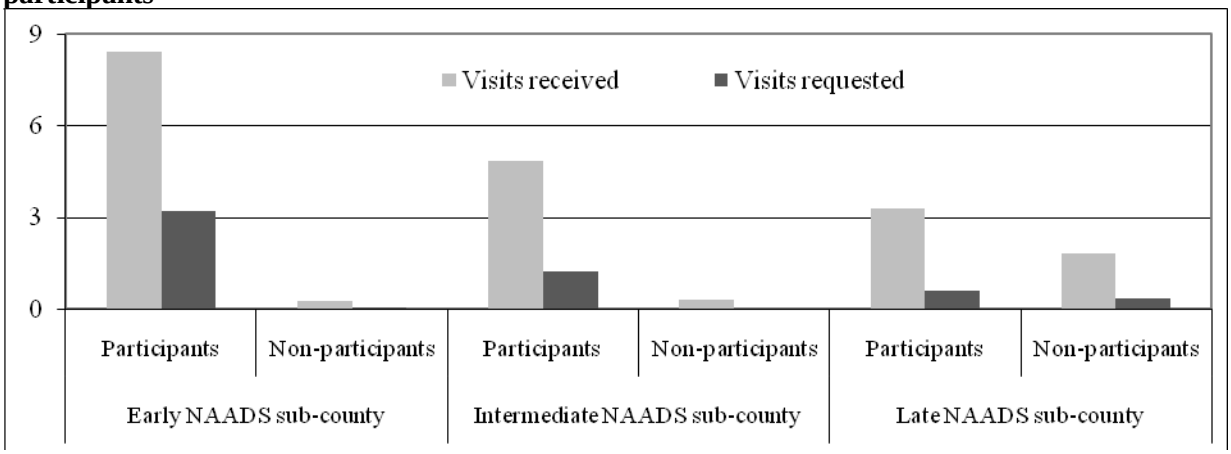
Impact of NAADS on demand for advisory services

Looking at the overall request for advisory services and without controlling for other factors likely to affect it, Figure 8 shows that the NAADS program led to an increase in the demand for overall advisory services among NAADS participants than among those not participating in the program. The number of extension visits requested is greater the longer the NAADS program has been in a given sub-county. Controlling for other factors and looking at the demand for specific improved technologies and practices, the regression results in Table 15 show the impact of NAADS is more on the demand for soil and water conservation (SWC) technologies than for the other technologies and practices. It is only for SWC that the NAADS variable has the same sign and is statistically significant using both IV and 2SWR methods. As we expect, the impact of NAADS would tend to be overestimated when the IV method is used, which is evidenced by the

[12] Crop management practices include: plant spacing, row planting, pruning, de-suckering, seed selection, thinning, weeding, time of planting, and budding/grafting.

larger magnitude of the coefficient on the NAADS variable in the IV regression as well as the relative statistical insignificance of the same coefficient with the 2SWR method.

Figure 8. Number of extension visits received and requested by NAADS participants and non-participants



Source of data: NAADS-IFPRI 2007 household survey.

The later suggests that the results are not robust for many of the improved technologies and practices considered here. Regarding soil fertility, for example, the impact of participation in the NAADS program is negative with the IV method but positive with the 2SWR method; on the demand for soil fertility in the matched sample regression. This applies mostly to organic fertilization, where, as we will see later (Table 16), nearly all farmers said they used organic fertilizers versus less than 15 percent who said they used inorganic fertilizers.

Consistent with Benin et al. (2007), who observed that NAADS advisory services were predominantly focused on production technologies, the results in Table 15 shows that the NAADS program did not have a significant impact on demand for advisory services on post-production technologies (i.e., post-harvest and agricultural marketing). The capacity of NAADS to provide marketing services is still limited (Ramirez and Quarry 2004). Providers of marketing information systems are very few and they also face poor market information (Ibid). This suggests the need to increase the capacity of market information service providers to provide better market information and for improving the market information through the enterprise development and market linkage component of NAADS. Likewise, provision of post-harvest technologies is still weak and also need to be enhanced.

Together, the above results suggest that the NAADS program may be slow in achieving its objective of increasing the capacity of farmers to demand advisory services on the improved technologies and practices considered here. On the other hand, we may only be observing the tail end of the demand since we use responses of farmers' demand in 2004–2007 rather than a complete panel data. For example, as we will see later, participation in the NAADS program is associated with widespread adoption of several improved technologies and practices in 2000–2004. This could contribute to the negative or insignificant impact of NAADS in some of the regressions, including the demand for livestock breeds. Benin et al. (2007) showed that the rate

Table 15. Instrumental variables and two-stage weighted probit regression results of the determinants of demand for advisory services

	Crop varieties		Crop management		Fertility management		Soil conservation	
	IV	2SWR	IV	2SWR	IV	2SWR	IV	2SWR
NAADS_total	1.482***	-0.062	1.576***	0.045	-1.712***	0.570**	2.037***	1.167***
Gender of head	0.037	-0.361	0.150	0.502	0.062	0.024	0.341*	0.517*
Ln Age of head	-0.085	-0.878**	-0.234	-0.162	-0.178	-0.063	-0.166	-0.644
Education (cf.: no formal education)								
Primary education	-0.123	-1.249***	-0.181	0.093	0.547	1.109**	0.422*	0.293
Post primary education	0.143	-0.745*	0.025	0.333	0.830*	1.489***	0.358	0.203
Ln Household size	0.067	-0.058	-0.079	0.166	0.121	0.041	0.153	0.234
Membership in other organizations	0.007	0.141	0.024	-0.168	-0.137	-0.211	-0.377**	-0.474*
Income strategy (cf.: crops)								
Livestock	-0.232	-0.432	-0.575**	-0.821*	-0.741*	-0.626	-0.078	0.013
Other agriculture	0.045	0.273	0.079	0.107	0.002	-0.083	-0.041	-0.264
Non-farm	-0.005	0.057	-0.127	-0.022	-0.091	0.103	-0.276*	-0.421
Ln Land owned	0.088	0.003	-0.178	-0.519	0.043	0.062	-0.465	-0.596
Ln Crop area	0.007	-0.114	0.054	0.216	0.064	0.037	0.399**	0.462***
Ln productive assets	0.016	-0.026	0.022	0.082	-0.014	-0.015	0.000	0.065
Ln Distance to service:								
Credit	0.015	-0.146	0.035	0.435***	-0.030	-0.050	0.036	0.094
All-weather road	0.049	-0.112	0.253***	0.252	0.024	0.005	-0.067	0.022
Markets	0.022	-0.124	-0.036	-0.157	-0.188*	-0.212*	0.001	0.055
Region (cf.: Central)								
Eastern	-0.630***	-0.568**	-0.486**	-1.067***	-0.564**	-0.663**	-1.255***	-2.308***
Northern	-0.894***	-0.417	-0.502*	-0.648*	-1.216**	-1.236***	-1.354***	-1.991***
Western	-0.991***	-0.697**	-0.800***	-1.248***	-0.787***	-0.959***	-1.118***	-1.595***
Intercept	-1.014	5.135***	-0.825	-1.125	1.517	-1.262	-1.065	0.907

See Table 11 for detail description of variables. Ln means transformation by natural logarithm. N.e. means not estimated. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.
Source of data: NAADS-IFPRI 2007 household survey.

Table 15 continued.

	Post Harvest		Agro forestry		Livestock breeds		Marketing	
	IV	2SWR	IV	2SWR	IV	2SWR	IV	2SWR
NAADS_total	-0.481	-0.731	0.227	0.146	-1.914***	-0.031	-0.086	0.047
Gender of head	-5.996	n.e.	-6.610	n.e.	-0.340	-0.295	-0.308	-0.344
Ln Age of head	0.202	-0.684	-0.554	-1.193**	0.277	0.089	-0.736	-0.950
Education (cf.: no formal education)								
Primary education	n.e.	n.e.	-0.606	-0.186	0.061	-0.197	-0.209	-0.223
Post primary education	n.e.	n.e.	-0.210	0.238	0.093	0.071	0.346	0.630
Ln Household size	0.363	0.715	0.550	0.510*	0.159	0.177	0.368	0.450
Membership in other organizations	-0.263	0.224	-0.147	-0.151	0.213	0.582**	0.436	0.702*
Income strategy (cf.: crops)								
Livestock	-6.009	n.e.	-6.005	n.e.	-0.314	0.264	n.e.	n.e.
Other agriculture	-1.388***	-2.249***	-0.216	-0.392	-0.379	-0.629**	n.e.	n.e.
Non-farm	0.165	0.066	-0.431	-0.548*	-0.110	-0.137	-0.001	-0.193
Ln Land owned	-1.109	-0.074	-0.272	-0.016	-0.084	0.203	0.168	0.291
Ln Crop area	0.085	-0.081	0.274	0.376*	-0.076	-0.249	0.007	-0.214
Ln productive assets	0.197*	0.244**	0.021	0.013	0.108**	0.172***	0.115	0.100
Ln Distance to service:								
Credit	0.094	-0.196	-0.060	-0.218	0.064	0.099	-0.119	-0.170
All-weather road	0.122	0.200	0.373*	0.174	-0.185	-0.063	-0.145	-0.258
Markets	0.207	0.352	0.406**	0.258	-0.028	0.106	0.390***	0.447***
Region (cf.: Central)								
Eastern	-0.845**	-1.093**	-0.563	-0.234	-0.561**	-0.689*	-1.378**	-1.621***
Northern	-1.129*	-1.877***	-1.249*	-1.243**	-0.774**	-1.381***	-0.861	-0.898
Western	-1.117***	-1.847***	-1.260***	-1.408***	-0.799***	-1.371***	-0.614*	-0.633*
Intercept	-3.190	-0.477	-0.508	2.398	-0.920	-2.986	-1.040	-0.839

See Table 11 for detail description of variables. Ln means transformation by natural logarithm. N.e. means not estimated. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.
Source of data: NAADS-IFPRI 2007 household survey.

of adoption of new beef cattle and pig enterprises for the 2000–2004 periods for NAADS participants was higher than non-participants. The weak demand for improved soil fertility management practices could be due to low investment that the NAADS program may be putting in soil fertility management practices in the technology development and demonstration sites. For example, as we will see later, the NAADS expenditure on fertilizer was much lower than expenditure on planting materials, livestock and other technologies (see Figure 12). These results raise concern on the sustainability of NAADS' strategy since low demand and adoption of improved soil fertility technologies and practices would lead to soil fertility mining and in turn lead to lower productivity in the long-run.

Effects of other factors on demand for advisory services

Female headed households were more likely to demand soil conservation technologies than male headed households. However, gender of the household head did not significantly affect the demand for any other improved technologies or practices included in this study. This is consistent with Faye and Deininger (2005) who used a much larger sample and found that access to extension services was not significantly different across gender of household headship. Since access of extension and other rural services generally tend to be biased against women farmers (Blackden et al. 2006; Doss 2001), these results suggest that the positive impact of the NAADS program on empowerment of farmers to demand advisory services could have been more for women than men to an extent that it eliminated the differences between them.[13]

Younger farmers are more likely to demand crop improved varieties and agroforestry technologies than older farmers. This underscores the challenge of introducing new approaches and technologies to older farmers who are set in their ways and may not be open to the new demand-driven approaches. However, age of the household head did not have a significant impact on demand for the other technologies and practices included in this study.

Education is expected to increase demand for advisory services since better educated farmers are likely to have higher capacity to demand and interpret new technologies (Asfaw and Admasie 2004). Accordingly, household heads with primary education and post-primary education were more likely to demand soil fertility management practices compared to those with no formal education. Likewise, those with primary education were more likely to demand soil conservation technologies, although the effect is not significant in the weighted regression. However, household heads with formal education were less likely to demand crop improved varieties than those with no formal education. This could be due to the fact that the farmers with formal education could have demanded for new crop varieties before 2004. Studies have also shown that farmers with better education are less likely to adopt labor intensive technologies since the opportunity cost of their labor is higher and that they have alternative livelihoods that compete for labor and other household resources. For example, Birkhaeuser et al. (1991) reviewed 10 studies and found that level of education was negatively associated with agricultural productivity.

[13] We did not collect demand data in the 2004 survey, hence cannot show the gender (or other factor) differences in demand for advisory services before NAADS started.

Membership in farmer organizations other than participation in the NAADS program was negatively associated with demand for soil conservation. It is possible such organizations promote technologies that compete for labor and other resources with soil conservation technologies. For example, the results also show that membership in farmer organizations is associated with greater demand for livestock breeds and marketing activities.

Larger households were associated with greater probability to demand agroforestry technologies. This could be due to the larger family labor that addresses the potential labor intensive agroforestry technologies, e.g., those that need to cut and carry leguminous fodder trees. Greater ownership of land was associated with greater probability to demand soil conservation and agroforestry technologies. Likewise, the households with larger values of productive assets were associated with greater probability to demand post-harvest and livestock breed technologies. The results are consistent with Nkonya et al. (2008) and Frisvold et al. (2001) who observed higher demand for farmers with greater resource endowment.

Contrary to expectations, distance to all-weather road and output markets did not have significant impacts on demand for advisory services on most of the technologies included in this study. This suggests that NAADS empowerment efforts may have helped farmers in remote areas to increase their capacity to demand for advisory services. For technologies in which distance to road and market showed significant impact on demand, households in remote areas were associated with greater likelihood to demand advisory services than those closer to roads and markets. For example, distance to all-weather road and output market was positively associated with demand for crop management technologies. The results are contrary to Platteau (2004) who observed that farmers in remote areas are less empowered to demand for agricultural advisory services or other services. The results could also indicate the poor provision of advisory services in remote areas and hence greater need for such services.

Distance to sources of credit (bank and microfinance institutions) had mixed impacts on demand for advisory services. Proximity to source of credit was associated with greater likelihood to demand soil fertility management practices but lower likelihood to demand agroforestry and marketing technologies. The negative impact of access to credit could be due to the tendency of farmers to use credit to invest in non-farm activities that have higher returns than agricultural enterprises. This leads to competition for household resources and shift away from agricultural production. This could then lead to lower share of marketed surplus and hence limited demand for marketing advisory services. On the other hand, access to credit could help to finance adoption of fertility management practices such as fertilizer – and hence increased demand for advisory services on such technologies. Farmers also could be intensifying on smaller pieces of land to maximize their more expensive labor inputs.

As expected, having livestock as a major source of income was associated with lower likelihood to demand crop management practices; and having other agriculture (especially beekeeping and aquaculture) as major sources of income were associated with lower likelihood to demand improved crop varieties, soil fertility management practices, livestock breeds, and post-harvest technologies, due to less focus on crop and livestock production for such farmers. It is possible that farmers who depend on other agricultural enterprises likely demand for advisory services on such enterprises. Having non-farm income-earning activities was associated with lower

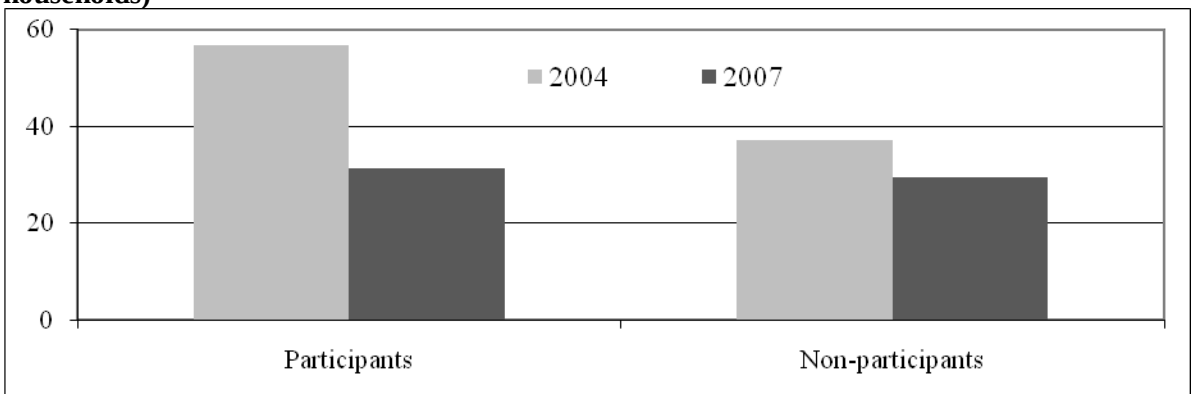
likelihood to demand for soil conservation and agroforestry technologies, which could be due to the high labor intensity involved. However having non-farm activities generally does not have a significant impact on the probability to demand advisory services in most of the technologies analyzed in this study.

The demand for advisory services for all technologies considered in this study was higher in the Central Region, which has the highest access to roads and other rural services compared to the other three regions. Hence, efforts to increase the capacity of farmers to effectively demand advisory services need to be directed to other regions with lower capacity.

5.3. Adoption of New Enterprises

Adoption of profitable enterprises and technologies is a key strategy of PMA's goal of modernizing agriculture. Hence this study analyzed the impact of NAADS on adoption of new enterprises. Farmers were asked to provide information on any new enterprises they had adopted between 2000 and 2004 and between 2004 and 2007. Figure 9 shows that adoption of new enterprises has declined over time, although NAADS participants adopted more new enterprises than their non-participant counterpart. For example, more than 50 percent of the NAADS participants adopted a new crop enterprise between 2000 and 2004 compared to 34 percent of the non-participants. The decline in adoption of new enterprises over time is expected as farmers settle on those that meet their needs, after having tried out several alternatives.

Figure 9. Adoption of new enterprises by NAADS participants and non-participants (percent of households)



Notes: $\hat{\delta}_{DID}$ = -0.15** , $\hat{\delta}_{PSM}$ = -0.26***; Percentage change = -47

Source of data: Panel from NAADS-IFPRI 2004 and 2007 household surveys.

5.4. Adoption of Improved Production Technologies and Practices

This section looks at the impact of NAADS on adoption of agricultural improved production technologies and practices. Here, we consider use of crop improved varieties, recommended spacing and planting practices, use of pesticides, use inorganic fertilizers, and use of livestock

improved breeds. Based on the matched sample, we first look at the results from simple differences in the percentage of NAADS participants and non-participants that adopted the selected improved technologies and practices without controlling for other factors that are likely to affect adoption (Table 16), and then we look at the results from estimating a panel-data random-effects probit model that accounts for other factors (Table 17). We use the random effects estimator rather than the fixed-effects estimator; the conditional fixed-effects estimator is difficult to obtain, while the unconditional fixed-effects estimator is biased.

Impact of NAADS on adoption

Table 16 shows that a significantly greater percentage of NAADS participants adopted the selected agricultural improved production technologies and practices in both 2004 and 2007 compared to their non-participant counterparts. Looking at the dynamics between 2004 and 2007 shows that not only did a greater percentage of the NAADS participants maintain their adoption, but a greater proportion of those that did not adopt in 2004 did adopt in 2007. Interestingly, we find a greater proportion of the NAADS participants dropping the technologies they had adopted earlier. The percentages of households in this category were relatively small compared to the others, however; and the difference in the percentages between the NAADS participants and non-participants was also not statistically significant.

Compared to 2004 for both NAADS participants and non-participants, adoption was greater in 2007 for improved crop varieties and livestock breeds, but lower for adoption inorganic fertilizers and pesticides (for NAADS participants). The decline over time in adoption of inorganic fertilizers, is most likely due to its lack of profitability (Pender et al. 2004) and the dramatic increase in fertilizer prices since 2006 (Dorward and Poulton 2008). This is troubling and raises concern on the sustainability of the NAADS strategy as promotion of improved planting without adequate soil fertility management would lead to soil fertility mining and undermine any potential productivity gains in the long-run.

When we control for other factors that are likely to affect adoption of the agricultural improved technologies and practices, we find that the positive impact of the NAADS program is significant in the adoption of crop improved varieties and use of recommended spacing and planting practices (Table 17). The results also show that the longer the NAADS program has been in the sub-county, the greater the likelihood of having more farmers adopt different improved technologies and practices; with the exception of inorganic fertilizers, where the impact was marginally negative in the intermediate NAADS sub-county, and livestock improved breeds, where there was no significant impact. The negative impact on use of inorganic fertilizers in the intermediate NAADS sub-county is troubling, but it does reflect underlying problems of high cost of acquisition of inorganic fertilizers and lack or profitability of their use (Pender et al. 2004; Nkonya et al. 2005).

Table 16. Adoption of crop and livestock improved production technologies and practices in 2004 and 2007, and change between 2004 and 2007 (percentage of households)

	NAADS participants	NAADS non-participants
Crop improved varieties		
2004	52.54	23.45
2007	68.31	53.34
Change between 2004 and 2007		
2004=1, 2007=0	8.67	6.80
2004=0, 2007=0	19.64	40.14
2004=1, 2007=1	23.72	33.33
2004=0, 2007=1	47.96	19.73
Recommended spacing and planting		
2004	64.33	46.69
2007	63.74	41.96
Change between 2004 and 2007		
2004=1, 2007=0	17.23	24.26
2004=0, 2007=0	20.00	36.03
2004=1, 2007=1	19.08	22.06
2004=0, 2007=1	43.69	17.65
Pesticides		
2004	36.59	17.06
2007	26.77	21.67
Change between 2004 and 2007		
2004=1, 2007=0	19.69	9.56
2004=0, 2007=0	54.15	66.91
2004=1, 2007=1	13.54	19.12
2004=0, 2007=1	12.62	4.41
Inorganic fertilizers		
2004	15.36	13.81
2007	8.31	8.17
Change between 2004 and 2007		
2004=1, 2007=0	11.38	8.82
2004=0, 2007=0	80.92	85.29
2004=1, 2007=1	5.85	3.68
2004=0, 2007=1	1.85	2.21
Livestock improved breeds		
2004	24.57	11.27
2007	30.92	29.79
Change between 2004 and 2007		
2004=1, 2007=0	9.72	6.02
2004=0, 2007=0	57.89	59.04
2004=1, 2007=1	20.65	27.71
2004=0, 2007=1	11.74	7.23

Source of data: Panel from NAADS-IFPRI 2004 and 2007 household surveys.

Effects of other factors on adoption

Table 17 also shows that there are several factors besides the NAADS program that have contributed to the adoption by farmers of different improved technologies and practices, particularly education, household size, membership in other organizations, ownership of land and other productive assets, non-farm income, and access to credit services. For example, post-primary education was associated with greater likelihood of adopting recommended spacing and planting practices, pesticides and livestock improved breed, while larger households were

associated with greater likelihood of adopting crop improved varieties, pesticides and livestock improved breeds. This later is not surprising given the relatively large labor requirements associated with those activities. Membership in other organizations and larger cultivated croplands were associated with greater likelihood of adopting crop improved varieties, recommended spacing and planting practices, and pesticides. The positive relationship between cropland and adoption is contrary to the inverse farm size-intensity relationship that has been found in many studies (Bhalla 1988; Lamb 2003). Ownership of other productive assets and non-farm income sources also have significant positive impacts on adoption, particularly use of crop improved varieties and livestock improved breeds. Better access to credit was associated with greater likelihood of adoption of crop improved varieties, pesticides, inorganic fertilizers and improved crop and livestock breeds. Actually, access to credit is the only variable besides household size with a consistent sign in four of the five adoption equations, which highlights the importance of addressing credit constraints for widespread adoption of agricultural improved technologies and practices.

In general, the likelihood of adopting improved technologies and practices was greater in the Central Region compared to the other regions, with the exception of use of pesticides whose adoption was greatest in the Eastern Region and use of recommended spacing and planting requirements whose adoption was greatest in the Northern Region.

Together, the results show that while adoption of agricultural improved technologies and practices was much more widespread among NAADS participants than their non-participant counterparts in 2004, adoption seem to have slowed down between 2004 and 2007 and even dropped in many households. This could be due to the fact that farmers who adopted technologies in the initial stages of the program (i.e. 2000–2004) do not have to adopt the same technologies in 2004–2007. Such farmers will focus on consolidating and understanding better the new technologies and/or adopting other technologies not considered in this study. However, the results also highlights the importance of sustaining the momentum gained by the NAADS program in the earlier years, which may be difficult to achieve with the program being rolled out to more districts and sub-counties, especially if the resources needed to cover the increasing population becomes severely compromised. On the other hand, the widespread adoption in 2004 among the NAADS participants compared to the non-participants could have been the result of targeting those that were already adopting improved technologies and practices. We cannot test this assertion, however, since we do not have pre-NAADS adoption levels, i.e. adoption in 2000. Therefore, the impact of the NAADS program on the adoption of agricultural improved technologies and practices between 2004 and 2007 is significantly more on use of crop improved varieties and recommended spacing and planting practices, than on use of pesticides, inorganic fertilizers, and livestock improved breeds.

Table 17. Panel random-effects probit regression results of use of crop and livestock production technologies and practices

	Crop improved varieties		Recommended spacing and planting		Pesticides		Inorganic fertilizers		Livestock improved breeds	
NAADS_total	0.421	***	0.256	**	0.091		0.148		0.153	
NAADS_years (cf.: after 2003)										
NAADS_year02/03	0.456	***	0.667	***	0.519	***	-0.419	*	-0.238	
NAADS_year01/02	0.627	***	0.689	***	0.647	***	0.022		0.035	
Gender of head	0.151		0.080		-0.263	*	0.109		0.088	
Ln Age of head	0.038		-0.130		-0.299	*	-0.187		-0.274	
Education (cf.: no formal education)										
Primary education	0.011		0.251	*	-0.043		0.163		0.025	
Post primary education	0.003		0.474	***	0.394	**	0.329		0.355	*
Ln Household size	0.267	***	0.133		0.218	**	0.064		0.231	**
Membership in other organizations	0.423	***	0.448	***	0.438	***	-0.095		0.139	
Income strategy (cf.: crops)										
Livestock	-0.370		-0.164		-0.360		-0.143		-0.117	
Other agriculture	-0.300		-0.230		-0.333		0.052		0.105	
Non-farm	0.202	*	0.034		-0.235	*	0.043		0.251	*
Ln Land owned	-0.089	*	-0.026		-0.047		-0.068		0.233	***
Ln Crop area	0.146	***	0.184	***	0.125	**	-0.038		-0.051	
Ln productive assets	0.106	***	0.034		0.016		0.051		0.152	***
Ln Distance to service:										
Credit	-0.098	*	-0.009		-0.108	*	-0.259	***	-0.165	***
All-weather road	-0.025		0.021		0.011		0.020		-0.048	
Markets	0.052		-0.026		0.047		0.031		-0.120	
Region (cf.: Central)										
Eastern	-0.101		-0.377	**	0.350	**	-0.474	**	-0.690	***
Northern	0.048		0.818	***	-0.121		0.055		-1.169	***
Western	-1.059	***	-0.581	***	-0.029		-0.388	**	-0.588	***
Intercept	-2.183	***	-0.821		-0.816		-0.719		-0.937	
Wald chi-square	222.700	***	143.180	***	76.200	***	36.370	**	118.870	***

See Table 11 for detail description of variables. Ln means transformation by natural logarithm. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.

Source of data: Panel from NAADS-IFPRI 2004 and 2007 household surveys.

5.4. Crop and Livestock Productivity

In this section we analyze the impact of NAADS and factors on crop and livestock productivity. *Crop productivity* is measured by the value of total crop output per acre of cultivated land, while *livestock productivity* is made up of gain in the stock of animals and value of products (milk, cheese, meat, etc.) per tropical livestock unit (TLU).[14] The change in stock of livestock was obtained over a four-year period (2000-2004) in the 2004 survey and over a three-year period (2004-2007) in the 2007 survey, and so we divided the change by 4 and 3, respectively, to obtain the average gain in 2004 and 2007, respectively.[15] Information on livestock product was only obtained in the 2007 survey, but farmers were asked to provide their perception in production 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 assigned 75 percent increase (decrease) in the production if farmers responded that production had increased (decreased) a lot, 25 percent increase (decrease) in the production if farmers responded that production had increased (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. Descriptive statistics of these two productivity indicators in 2004 and 2007 are shown in Table 11.

As presented in the methodology section, we assessed the impact of NAADS on these indicators using the four methods of DID, PSM, 2SWR and IV, based on the matched sample of the household panel data and different specifications of the model including the matching technique and inclusion/exclusion of adoption of technologies and practices and lagged productivity variables. This is done to assess the robustness of the results. The influence of other factors, measured as change between the 2004 and 2007 levels, is assessed using the 2SWR and IV methods.

Impact of NAADS on crop and livestock productivity

Table 18 shows that the NAADS program has had mixed (both negative and positive) impacts on crop and livestock productivity between 2004 and 2007 depending on the method of assessment and model specification. However, the impacts are insignificant irrespective of the method of assessment and model specification. These results are quite different when we assess the impacts based on the other definition of participation in the NAADS program: membership in a NAADS-participating farmer group only (*NAADS_direct*), which aims at capturing the direct effects; as opposed to the previous one that includes indirect participants (*NAADS_total*), i.e. farmers who said they were not members of a NAADS-participating farmer group but received services from a NAADS service provider or community-based facilitator (CBF), which aims at capturing the total effects. The main difference regarding crop productivity is that the direct impact of NAADS is positive, irrespective of the method of assessment and model specification. Also, the impacts are significant with the IV method when the initial value of crop productivity is controlled for.

[14] One TLU is equivalent to one cow, using the following conversion rates: 0.36 for pigs, 0.09 for sheep and goats, and 0.01 for poultry.

[15] The change in the value of the stock of livestock was calculated as: ending stock plus the number born, sold and given away, less the number acquired and the beginning stock.

Regarding livestock productivity, however, the negative impacts are enhanced and significant with the IV method (whether the initial value of productivity is not controlled for or not) and 2SWR method (when the initial value of crop productivity is not controlled for). These mixed results are consistent in many ways with the previous findings regarding the limited positive (and sometimes negative) impact of the NAADS program on the demand and adoption of improved production technologies and practices.

Together, these results suggest that the impact of the NAADS program is direct only. The average treatment effect on the treated (ATT) of the program on crop productivity is up to 29 percent increase in productivity for NAADS' direct participants over non-participants. The spillover or indirect effects has not yet manifested. Regarding livestock production, however, the results imply that NAADS has contributed to a decline in productivity among the direct participants compared to their non-participant counterparts. The ATT of the program on livestock productivity is about 27-45 percent decline in productivity for NAADS' direct participants compared to non-participants. It is possible that NAADS farmers who adopted new livestock technologies between 2004 and 2007 were still learning and investing in the new technologies to an extent that it reduced their productivity in the initial stages. Hence, analysis of the long-term impacts of NAADS on livestock productivity could be positive.

Table 18. Impact of NAADS on change between 2004 and 2007 in crop and livestock productivity (percent difference between NAADS participants and non-participants)

	NAADS_total		NAADS_direct	
	Crop productivity	Livestock productivity	Crop productivity	Livestock productivity
DID				
Excluding initial values	-13.09		0.79	
Including initial values	-0.79		20.38	
PSM				
Kernel matching	-1.60	24.10	-2.30	13.90
Nearest 5 neighbors matching	16.80	-8.20	8.60	-6.60
Nearest 10 neighbors matching	12.30	-5.50	4.30	-3.10
IV				
Including adoption variables				
Excluding initial values	2.67	-8.27	21.19	-41.16 **
Including initial values	4.78	-4.96	28.86 **	-33.77 *
Excluding adoption variables				
Excluding initial values	-7.65	-7.62	25.25	-36.96 *
Including initial values	-4.57	4.55	30.77	-27.64
2SWR				
Including adoption variables				
Excluding initial values	-3.83	-7.04	13.42	-44.44 **
Including initial values	-6.81	-7.55	16.00	-34.73
Excluding adoption variables				
Excluding initial values	-15.09	-3.76	18.04	-42.25
Including initial values	-17.99	5.44	18.30	-30.81

*, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.
Source of data: Panel from NAADS-IFPRI 2004 and 2007 household surveys.

Effects of other factors on change in crop productivity

Changes in other factors that have significantly influenced change in crop productivity (i.e. value of total crop production per acre) between 2004 and 2007 include changes in use of crop improved varieties and inorganic fertilizers, commercialization, land and non-land assets, and access to all-weather roads (Table 19). Among the improved technologies and practices, increases in the use of crop improved seeds and inorganic fertilizers have contributed the most to raising crop productivity, which is not surprising; and the results are robust, i.e. irrespective of the estimation method and model specification. Increased commercialization, measured by the share of crop output that is marketed, has also been important for raising the value of production, probably due to higher prices obtained by farmers. Increase in crop productivity is positively associated with increase in land ownership and non-land productive assets, although the former is significant with the IV method only without controlling for the initial value of crop productivity, while the later is significant with both methods but only when initial value of crop productivity is controlled for. Increase in crop productivity also is positively associated with improvement in access to all-weather roads but negatively associated with increase in cultivated crop area. While the later is consistent with the inverse farm size-intensity relationship found in many studies, the results should not be misinterpreted to mean that crop areas and farmlands in Uganda should be reduced in order to increase crop yield. This is because scale economies are not being exploited, and so finding ways to improve productivity as farmers increase their farm sizes should take precedence.

Effects of other factors on change in livestock productivity

Changes in other factors that have significantly influenced change in livestock productivity (i.e. value of total livestock output per TLU) between 2004 and 2007 are similar to those affecting change in crop productivity. They include changes in use of livestock improved breeds, age of household head, land and non-land assets, and access to all-weather roads (Table 20). Increase in the use of improved breeds has contributed significantly to raising livestock productivity, which is not surprising. Increase in livestock productivity is positively associated with aging household heads and improvement in access to all-weather roads; although the former is significant with the IV method only and when use of improved breeds is excluded, while the later is significant also with the IV method only but without controlling for the initial value of livestock productivity. Increase in livestock productivity, on other hand, is negatively associated with increase in land ownership and increase in cultivated crop area, which most likely reflects substitution of pursuing crop or livestock production as the household's main source of income and livelihood.

Table 19. Instrumental variables and two-stage weighted regression results of change between 2004 and 2007 in the logarithm of the value of total crop output per acre

	Instrumental Variables (IV)				Two-stage weighted regression (2SWR)			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
NAADS_total	0.026	0.047	-0.080	-0.047	-0.039	-0.071	-0.164	-0.198
Δ Use of technologies								
Improved seeds	0.357 ***	0.255 **			0.325 ***	0.221 **		
Spacing	-0.112	-0.149			-0.114	-0.118		
Pesticides	0.000	0.030			0.011	0.064		
Inorganic fertilizer	0.332 *	0.220			0.539 ***	0.406 ***		
Δ Market shares								
Crop	0.007 ***	0.008 ***			0.007 ***	0.008 ***		
Δ Gender of head	0.041	-0.010	0.019	-0.037	0.254	0.041	0.255	0.036
Δ Ln Age of head	-0.052	-0.006	-0.241	-0.169	-0.231	-0.100	-0.414	-0.298
Δ Education (cf.: no change)								
Reduction	0.057	-0.064	-0.014	-0.119	0.053	-0.004	0.008	-0.037
Improvement	-0.017	0.062	-0.092	0.001	-0.097	0.045	-0.281	-0.101
Δ Ln Household size	0.000	0.009	0.021	-0.003	-0.098	-0.091	-0.054	-0.081
Δ Ln Land owned	0.161 *	0.090	0.190 **	0.110	0.116	0.072	0.143	0.098
Δ Ln Crop area	-0.538 ***	-0.363 ***	-0.565 ***	-0.386 ***	-0.532 ***	-0.371 ***	-0.564 ***	-0.400 ***
Δ Ln Productive assets	0.034	0.057 **	0.040	0.060 *	0.067	0.081 **	0.067	0.078 *
Δ Ln Distance to service:								
Credit	0.081	-0.048	0.211	0.039	-0.160	-0.188	-0.108	-0.148
All-weather road	-0.445 ***	-0.604 ***	-0.564 ***	-0.700 ***	-0.002	-0.085	-0.062	-0.177
Markets	-0.008	-0.464	-0.169	-0.610	-0.087	-0.308	-0.128	-0.378
Ln Crop output_2004		-0.612 ***		-0.626 ***		-0.614 ***		-0.631 ***
Intercept	0.101	7.353 ***	0.216	7.613 ***	0.059	7.422 ***	0.191	7.731 ***
Fisher's *F*-test	6.940 ***	17.560 ***	7.960 ***	21.220 ***	5.670 ***	9.440 ***	4.930 ***	11.930 ***
R-squared	0.239	0.418	0.182	0.373	0.254	0.408	0.185	0.351

With the exception of NAADS_total and unless otherwise noted, the explanatory variables are change (represented by Δ) between 2004 and 2007 variables. See Table 11 for detail description of variables. Ln means transformation by natural logarithm. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.

Source of data: Panel from NAADS-IFPRI 2004 and 2007 household surveys.

Table 20. Instrumental variables and two-stage weighted regression results of change between 2004 and 2007 in the logarithm of the value of total livestock output per TLU

	Instrumental Variables (IV)				Two-stage weighted regression (2SWR)			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
NAADS_total	-0.086	-0.051	-0.079	0.044	-0.073	-0.078	-0.038	0.053
Δ Use of technologies								
Livestock breeds	0.289	0.354 *			0.219	0.295 *		
Δ Market shares								
Livestock	-0.004	-0.002			-0.004	-0.002		
Δ Gender of head	0.281	0.189	0.134	0.059	0.378	0.291	0.156	0.098
Δ Ln Age of head	0.830	0.933	1.040 *	1.117 **	0.628	0.605	0.757	0.722
Δ Education (cf.: no change)								
Reduction	0.168	0.084	0.044	-0.011	-0.013	-0.028	-0.115	-0.104
Improvement	-0.194	-0.061	-0.350	-0.178	-0.318	-0.138	-0.371	-0.186
Δ Ln Household size	0.019	0.195	-0.115	0.133	0.005	0.209	-0.176	0.105
Δ Ln Land owned	-0.235 *	-0.162	-0.190	-0.108	-0.257 *	-0.165	-0.220 *	-0.125
Δ Ln Crop area	0.034	-0.020	-0.015	-0.070	0.072	0.007	0.032	-0.036
Δ Ln Productive assets	-0.273 ***	-0.214 **	-0.125	-0.123 *	-0.225 **	-0.181 *	-0.094	-0.095
Δ Ln Distance to service:								
Credit	-0.268	-0.130	-0.480	-0.321	0.175	0.181	0.058	0.080
All-weather road	0.465 ***	0.138	0.589 ***	0.258	0.230	-0.089	0.322	-0.038
Markets	-0.654	-0.637	-1.042	-0.862	-0.641	-0.496	-0.912	-0.642
Ln Livestock output_2004		-0.465 ***		-0.488 ***		-0.483 ***		-0.507 ***
Intercept	0.967 ***	6.294 ***	1.115 ***	6.626 ***	0.955 ***	6.502 ***	1.085 ***	6.806 ***
Fisher's *F*-test	5.140 ***	8.870 ***	4.130 ***		2.320 ***	4.470 ***	1.290	2.810 ***
R-squared	0.133	0.268	0.073		0.113	0.252	0.054	0.220

With the exception of NAADS_total and unless otherwise noted, the explanatory variables are change (represented by Δ) between 2004 and 2007 variables. See Table 11 for detail description of variables. Ln means transformation by natural logarithm. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.

Source of data: Panel from NAADS-IFPRI 2004 and 2007 household surveys.

5.5. Commercialization of Agricultural Production

Another important area that the NAADS program seeks to address is the low commercialization of agricultural production. To assess the impact of NAADS on this issue, we applied the same four methods of DID, PSM, 2SWR and IV on three indicators of agricultural commercialization: percentage of crop output, livestock output, and total agricultural (crop, livestock, beekeeping and aquaculture) output that is sold by farmers. Descriptive statistics of the shares or output sold by farmers in 2004 and 2007 are shown in Table 11.

Impact of NAADS on marketed output

The results in Table 21 show that the NAADS program has had a small impact (whether positive or negative) on the shares of agricultural output sold by farmers, although the estimated impacts are significant mostly with marketed crop output. Based on the significant results, and direct participation in the NAADS program (i.e. *NAADS_direct*), we estimate the ATT to be up to 7 percent increase in crop sales for the NAADS participants over their non-participant counterparts, and up to 4 percent more sale of total agricultural production, although the later is not significant. The impact on sale of livestock products is mostly negative, although negligible.

These results suggest that the impact of the NAADS program on commercialization of agriculture is direct only, and small. The results reflect the weak post-production advisory capacity of NAADS and call for the need to strengthen this through recruitment of providers who specifically provide marketing services and information. The results also reflect the generally poor marketing services in the country. The NAADS program needs to shift activities upwards to higher value-chain activities, which is consistent with our finding of the shift in the interest of older NAADS groups away from basic agronomic and production practices towards the same higher value-chain activities.

Impact of other factors on change in marketed output

Changes in other factors that have significantly influenced changes in marketed crop, livestock and total agricultural output between 2004 and 2007 include changes in use of improved technologies, age and education of household head, and non-land productive assets (Tables 22 to 24). A change in the household head leading to an increase in the age is associated with an increase in marketed share of livestock output but a reduction in the marketed share of crop output l, although the variable is no longer significant when the initial level of marketed shares are controlled for. A change in the household head leading to an improvement in the level of education is associated with a reduction in marketed share of total agricultural output, while a reduction in the level of education is associated with an increase in the marketed share of livestock. The former is not longer significant when the initial level of marketed share is controlled for, but the result of the later is robust to controlling for the initial level of marketed share of livestock output. An increase in the value of non-land productive assets is associated with a reduction in marketed share of livestock and total agricultural output, probably due to shift to other non-land based income activities.

Table 21. Impact of NAADS on change between 2004 and 2007 in percent of agricultural output that is sold (difference between NAADS participants and non-participants)

	NAADS_total			NAADS_direct		
	Crops	Livestock	Total agriculture	Crops	Livestock	Total agriculture
DID						
Excluding initial values	-4.77	-3.33	4.17	1.45	-3.24	-0.01
Including initial values	0.05	0.26	0.20	6.10 **	0.01	3.53
PSM						
Kernel matching	0.74	-4.90	0.20	0.60	-4.60	0.40
Nearest 5 neighbors matching	6.70 **	-4.40	0.28	6.40 **	-2.20	-1.50
Nearest 10 neighbors matching	7.30 **	-4.20	0.87	7.00 ***	-3.10	-1.40
IV						
Including adoption variables						
Excluding initial values	0.07	23.95	2.32	-3.70	-1.46	-1.48
Including initial values	4.42	1.85	-1.99	2.37	0.21	2.07
Excluding adoption variables						
Excluding initial values	-14.03	12.82	-14.41	1.69	-2.77	0.90
Including initial values	0.23	1.65	-4.20	5.09 *	-0.03	3.26
2SWR						
Including adoption variables						
Excluding initial values	-14.38 ** *	0.49	-7.36	-3.51	-1.81	-1.47
Including initial values	-7.44	-0.17	-5.70	2.83	-0.47	1.98
Excluding adoption variables						
Excluding initial values	-12.03 **	0.76	-8.85 *	-1.01	-2.96	-0.66
Including initial values	-6.05	-0.10	-5.47	4.28	-0.78	2.81

*, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.
Source of data: Panel from NAADS-IFPRI 2004 and 2007 household surveys.

Table 22. Instrumental variables and two-stage weighted regression results of change between 2004 and 2007 in the percentage of total value of crop output that is sold

	Instrumental Variables (IV)				Two-stage weighted regression (2SWR)			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
NAADS_total	-11.437 *	-6.763	-7.205	-2.974	-14.384 ***	-7.436	-12.029 **	-6.049
Δ Use of technologies								
Improved seeds	4.554	4.573			6.116 *	4.235		
Spacing	5.279	2.771			5.673	2.786		
Pesticides	-0.321	-4.261			1.392	-2.920		
Inorganic fertilizer	0.390	-3.527			-0.018	-1.456		
Livestock breeds	6.616	2.587			8.330 *	5.014		
Δ Gender of head	0.882	-3.359	-2.554	-1.089	2.358	-1.374	2.878	0.345
Δ Ln Age of head	-16.698 *	-7.020	-23.534 ***	-11.023	-15.471 *	-5.246	-23.536 ***	-10.966
Δ Education (cf.: no change)								
Reduction	-1.458	6.106	-8.575	2.142	-0.626	5.581	-4.083	5.601
Improvement	-5.666	-0.599	-5.681	-1.064	-9.089	-2.211	-7.235	-0.527
Δ Ln Household size	-9.318	-6.137	-6.091	-4.271	-8.930	-5.671	-5.208	-3.883
Δ Ln Land owned	-1.855	-0.074	1.197	0.539	-2.214	-0.684	0.714	0.187
Δ Ln Crop area	0.325	-1.010	-1.556	-1.244	-0.459	-1.230	-2.042	-1.668
Δ Ln Productive assets	-1.051	0.439	-0.725	-0.091	-0.470	0.619	-1.286	-0.874
Δ Ln Distance to service:								
Credit	-1.347	2.103	4.160	3.039	-0.065	-2.171	1.662	-1.676
All-weather road	5.267	5.704	4.360	5.072 *	-8.523	-4.895	-10.141	-2.174
Markets	-12.359	-12.980	-12.959	-11.054	-8.372	-8.241	-11.421	-11.098
Market share_crop_2004		-0.884 ***		-0.857 ***		-0.843 ***		-0.860 ***
Intercept	4.599	28.261 ***	3.259	25.417 ***	6.354	28.075 ***	6.597	29.404 ***
Fisher's *F*-test	3.730 ***	12.320 ***		22.140 ***	1.600 *	11.630 ***	1.730 *	19.700 ***
R-squared	0.080	0.460		0.433	0.103	0.451	0.061	0.436

With the exception of NAADS_total and unless otherwise noted, the explanatory variables are change (represented by Δ) between 2004 and 2007 variables. See Table 11 for detail description of variables. Ln means transformation by natural logarithm. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.

Source of data: Panel from NAADS-IFPRI 2004 and 2007 household surveys.

Table 23. Instrumental variables and two-stage weighted regression results of change between 2004 and 2007 in the percentage of total value of livestock output that is sold

	Instrumental Variables (IV)				Two-stage weighted regression (2SWR)			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
NAADS_total	-0.046	0.218	-0.072	0.045	0.487	-0.173	0.760	-0.103
Δ Use of technologies								
Improved seeds	-13.504 ***	0.400			-11.809 ***	0.275		
Spacing	3.121	-1.457			4.852	-0.903		
Pesticides	9.452 ***	1.993 *			9.114 ***	1.085		
Inorganic fertilizer	-12.775 **	0.294			-16.833 ***	-1.500		
Livestock breeds	-0.311	-1.851			-1.812	-2.154		
Δ Gender of head	4.135	1.995	4.304	1.715	7.718	2.573	8.256	2.928
Δ Ln Age of head	29.713 ***	5.407	28.851 **	5.207	32.848 ***	5.635	28.978 **	5.387
Δ Education (cf.: no change)								
Reduction	-6.062	12.270 **	-7.718	11.842 **	-3.553	9.705 **	-5.348	9.397 **
Improvement	-7.098	2.276	-6.906	1.970	-8.610	2.543	-6.578	2.273
Δ Ln Household size	2.162	2.162	0.343	1.970	3.220	3.282	1.919	3.180
Δ Ln Land owned	-0.627	0.072	-0.778	-0.035	-0.309	0.510	-0.082	0.297
Δ Ln Crop area	-2.134	0.807	-1.150	0.786	-2.762	0.410	-1.812	0.452
Δ Ln Productive assets	0.538	-1.361 *	0.128	-1.289 *	1.001	-1.245 *	0.279	-1.159 *
Δ Ln Distance to service:								
Credit	2.473	0.484	0.895	0.862	-0.835	-0.197	-0.911	-0.063
All-weather road	-4.074	2.850 *	1.265	2.148	0.114	1.708 *	-0.808	1.635
Markets	10.995	-0.829	12.187	0.029	5.122	-0.094	4.682	0.276
Market share_lvst_2004		-1.017 ***		-1.017 ***		-1.009 ***		-1.013 ***
Intercept	-18.826 ***	4.106 **	-20.560 ***	4.134 **	-20.276 ***	3.995 **	-21.824 ***	3.861 **
Fisher's *F*-test	1.540 *	160.800 ***	0.830	200.560 ***	1.750 **	179.510 ***	0.750	252.380 ***
R-squared	0.098	0.882	0.034	0.880	0.099	0.895	0.032	0.894

With the exception of NAADS_total and unless otherwise noted, the explanatory variables are change (represented by Δ) between 2004 and 2007 variables. See Table 11 for detail description of variables. Ln means transformation by natural logarithm. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.

Source of data: Panel from NAADS-IFPRI 2004 and 2007 household surveys.

Table 24. Instrumental variables and two-stage weighted regression results of change between 2004 and 2007 in the percentage of total value of agricultural output that is sold

	Instrumental Variables (IV)				Two-stage weighted regression (2SWR)			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
NAADS_total	-5.448	-4.110	-6.225	-2.206	-7.357	-5.696	-8.848 *	-5.469
Δ Use of technologies								
Improved seeds	-4.344	2.881			-1.798	2.319		
Spacing	1.337	-0.092			3.887	0.719		
Pesticides	5.259	-1.548			6.621 *	-1.408		
Inorganic fertilizer	1.676	1.491			-4.348	0.122		
Livestock breeds	3.227	0.257			2.835	1.128		
Δ Gender of head	3.290	-0.887	-3.247	-0.323	5.127	-0.871	3.190	-0.392
Δ Ln Age of head	-1.691	0.364	-9.085	-2.385	1.163	0.786	-5.172	-1.631
Δ Education (cf.: no change)								
Reduction	-7.694	7.577	-13.550 **	2.179	-4.872	8.036	-9.143	6.383
Improvement	-6.301	-0.897	-9.396 *	-2.049	-10.291 *	-1.205	-10.139 *	0.004
Δ Ln Household size	-6.955	-3.150	-6.062	-3.581	-5.665	-1.559	-4.282	-2.686
Δ Ln Land owned	0.106	1.074	1.517	0.963	0.596	1.255	1.561	0.957
Δ Ln Crop area	-2.232	-0.595	-1.967	-0.660	-2.864	-0.741	-2.313	-0.752
Δ Ln Productive assets	-3.991 ***	-2.172 **	-2.447 ***	-1.365 **	-3.979 ***	-2.259 ***	-3.505 ***	-1.962 ***
Δ Ln Distance to service:								
Credit	-1.389	0.538	4.362	3.102	-1.684	-0.162	0.514	1.146
All-weather road	2.452	3.320	4.072	2.314	-1.276	-2.379	-2.807	-1.157
Markets	-5.385	-11.474	-4.807	-8.114	-7.733	-8.267	-8.662	-9.926
Market share_total_2004		-0.948 ***		-0.928 ***		-0.939 ***		-0.943 ***
Intercept	-4.288	20.385 ***	-2.941	19.830 ***	-3.598	20.828 ***	-1.495	22.439 ***
Fisher's *F*-test	2.500 ***	25.770 ***	3.950 ***	39.240 ***	1.890 **	29.930 ***	2.370 ***	48.400 ***
R-squared	0.090	0.612	0.076	0.582	0.106	0.626	0.084	0.613

With the exception of NAADS_total and unless otherwise noted, the explanatory variables are change (represented by Δ) between 2004 and 2007 variables. See Table 11 for detail description of variables. Ln means transformation by natural logarithm. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.

Source of data: Panel from NAADS-IFPRI 2004 and 2007 household surveys.

5.6. Income, Consumption Expenditure, and Food and Nutrition Security

5.6.1. Agricultural income per capita

In this section, we use the household panel data to analyze the impact of NAADS and other factors on agricultural income per capita, which is measured by the total value of crop, livestock, beekeeping and aquaculture output divided by the total number of household members. As before, we apply the four methods of DID, PSM, 2SWR and IV, based on different matching techniques and specifications of the models.

Impact of NAADS on change in income

Similar to the impact on crop productivity, Table 25 shows that the NAADS program has had significant positive direct impact on per capita agricultural income. Based on the significant results associated with direct participation in the program (i.e. *NAADS_direct*) and using the PSM and regression methods, we estimate the ATT to be 42-53 percent increase in per capita agricultural income for the NAADS participants over their non-participant counterparts. The more favorable impact of the program on total agricultural income, compared to income from crops and livestock, is due to additional substantial income for NAADS participants from high-value agricultural activities such as beekeeping and aquaculture.[16]

Table 25. Impact of NAADS on change between 2004 and 2007 in agricultural income per capita (percent difference between NAADS participants and non-participants)

	NAADS_total		NAADS_direct	
DID				
Excluding initial values	3.83		36.17	*
Including initial values	24.33		72.93	***
PSM				
Kernel matching	40.20	*	39.20	
Nearest 5 neighbors matching	45.30	***	52.60	***
Nearest 10 neighbors matching	38.90	***	49.70	***
IV				
Including adoption variables				
Excluding initial values	-0.27		8.39	
Including initial values	8.83		29.12	
Excluding adoption variables				
Excluding initial values	-1.52		19.48	
Including initial values	15.65		48.14	***
2SWR				
Including adoption variables				
Excluding initial values	-4.47		2.99	
Including initial values	3.75		22.30	
Excluding adoption variables				
Excluding initial values	-12.58		12.45	
Including initial values	4.52		42.02	**

*, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.
Source of data: Panel from NAADS-IFPRI 2004 and 2007 household surveys.

[16] It was not possible to analyze the impacts of NAADS on beekeeping and aquaculture since the number of farmers who reported these enterprises was very small.

The positive impact of NAADS on value of crops produced per unit area could have contributed to the large impact on per capita income but the small sample size of the panel data used increased the standard error – consequently reducing the significance of the NAADS impact. This demonstrates the effectiveness of the program in diversifying income and promoting more high-value activities.[17]

The observed weak impact of NAADS on income from especially crops and livestock, as well as from assessing the impacts using the broader definition of participation (i.e. *NAADS_total*), suggests that merely providing advice and information on improved technologies and practices to farmers without helping them to acquire the relevant technologies and services is not likely to yield any substantial payoffs. Farmers that participate directly in the program through membership of a NAADS-participating farmer group (captured by *NAADS_direct*) have access to grants for purchasing technologies and necessary advisory services. Thus, while all farmers may have access to NAADS' TDSs and CBFs, only those with access to NAADS' grants or other financial resources to acquire the technologies and necessary advisory services would benefit; suggesting that the anticipated large indirect or spillover effects of the program may not be realized.

The observed weak impact of the NAADS program on income from especially crops and livestock is also likely due to immaturity of the program in the sense of having key components in place. Although implementation of the program started in July 2001, transfer to and adoption by farmers of improved technologies and practices via grants for the establishment of TDSs and subsequent devolvement of the proceeds (i.e. technologies) from the TDS to farmers, which constitute the main pathways of impact,[18] takes place further down the road. The first couple years or so of the program focuses on farmer institutional development (FID) and service provider capacity development (SPCD). This is evident in Figure 3, which shows that relatively low ratios of expenditures on TDS to FID up to 2003/04 and of TDS to SPCD up to 2005/06. The revolving fund process could even be more protracted for livestock compared to crops, since the turnaround time for animals is longer.

The weak impact of the program could also be explained by the spillover of NAADS advisory services to non-participants. For example, TDS were established in the public domain where any farmer could benefit from observing and learning from the demonstrations even without receiving visits from NAADS advisory service providers. Hence the variable *NAADS_total* only partially captures the spillover of the NAADS program. Accounting fully for any diffusion or spillover to the entire community may be done by using community or other higher-level treatment effects —for example, by assuming that the entire village or sub-county is in the treatment group if NAADS is operating in the village or sub-county (Feder et al. 2003; Birkhaeuser et al. 1991). We did not take this approach since our evaluation was at the household level.

[17] Due to relatively small number of households engaged in beekeeping and aquaculture (about 10 percent of the total sample), we are unable to assess the impact of the NAADS program on incomes from these activities separately.

[18] As discussed earlier, the grant is initially used to finance the establishment of a TDS, whose proceeds become a revolving fund for members.

Table 26. Instrumental variables and two-stage weighted regression results of change between 2004 and 2007 in logarithm of agricultural income per capita

	Instrumental Variables (IV)				Two-stage weighted regression (2SWR)			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
NAADS_total	-0.003	0.085	-0.015	0.145	-0.046	0.037	-0.134	0.044
Δ Use of technologies								
Improved seeds	0.243 *	0.205 *			0.280 **	0.227 **		
Spacing	-0.050	-0.111			-0.057	-0.121		
Pesticides	0.139	0.108			0.034	0.008		
Inorganic fertilizer	0.294	0.399 ***			0.577 ***	0.664 ***		
Livestock breeds	0.201	0.250			0.191	0.267		
Δ Total market share	0.008 ***	0.007 ***			0.009 ***	0.008 ***		
Δ Gender of head	0.534 *	0.312	0.181	0.197	0.717 **	0.505	0.462	0.373
Δ Age of head	-0.461	-0.309	-0.146	-0.034	-0.554	-0.385	-0.253	-0.098
Δ Education (cf.: no change)								
Reduction	0.207	0.273	0.027	0.104	0.184	0.188	0.110	0.183
Improvement	-0.171	-0.069	-0.170	0.016	-0.086	0.005	-0.339	-0.087
Δ Household size	0.123	0.242	0.118	0.089	-0.023	0.107	0.105	0.072
Δ Income strategy (cf.: no change)								
To crops	-0.098	-0.146	-0.399	-0.375 *	-0.016	-0.041	-0.357	-0.332
To livestock	0.664 **	0.666 *	0.469	0.538	0.679 **	0.692 *	0.459	0.520
To other agriculture	0.585 **	0.679 ***	0.627 *	0.781 ***	0.762 ***	0.842 ***	0.710 **	0.856 ***
To non-farm	-0.538 *	-0.483 *	-0.411 *	-0.456 **	-0.416	-0.373	-0.457	-0.416 *
Δ Land owned	0.167 **	0.153 **	0.204 ***	0.203 ***	0.109	0.100	0.137	0.146 **
Δ Crop area	0.366 ***	0.236 ***	0.402 ***	0.198 ***	0.337 ***	0.217 ***	0.392 ***	0.197 ***
Δ Productive assets	0.059	0.083	0.038	0.051 *	0.038	0.063	0.060	0.069 *
Δ Distance to service:								
Credit	0.012	-0.052	-0.006	-0.042	-0.014	0.006	-0.002	0.033
All-weather road	-0.434 ***	-0.462 ***	-0.418 ***	-0.514 ***	-0.386 ***	-0.508 ***	-0.228	-0.354 *
Markets	0.035	-0.147	-0.149	-0.380	-0.088	-0.126	-0.139	-0.175
Ln Agricultural income_2004		-0.465 ***		-0.555 ***		-0.456 ***		-0.568 ***
Intercept	0.236	5.393 ***	0.300	6.401 ***	0.141	5.231 ***	0.266	6.535 ***
Fisher's *F*-test	4.860 ***	11.020 ***	7.220 ***	17.120 ***	5.850 ***	10.690 ***	5.940 ***	13.300 ***
R-squared	0.290	0.424	0.231	0.424	0.259	0.374	0.203	0.386

With the exception of NAADS_total and unless otherwise noted, the explanatory variables are change (represented by Δ) between 2004 and 2007 variables. See Table 11 for detail description of variables. Ln means transformation by natural logarithm. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.

Source of data: Panel from NAADS-IFPRI 2004 and 2007 household surveys.

Effect of other factors on change in income

As with changes in crop and livestock productivity, changes in several factors significantly influenced change in income between 2004 and 2007, including changes in use of crop improved varieties and inorganic fertilizers, commercialization, income sources, land assets, and access to all-weather roads (Table 26). Among the improved technologies and practices considered, increases in the use of crop improved seeds and inorganic fertilizers have contributed the most to raising income, which is not surprising. And the results are robust, i.e. irrespective of the estimation method and model specification. Increased commercialization, measured by the share of total agricultural output that is marketed, has also been important for raising incomes, due to higher prices obtained by farmers. Increase in income is positively associated with movement away from crop production activities towards high-value beekeeping and aquaculture production activities (which is consistent with the earlier discussion on their contribution to income), increase in land ownership and area cultivated, and improvement in access to all-weather roads. Movement towards non-farm activities tends to reduce income, which is also expected.

5.6.2. Consumption expenditure

Information on consumption expenditure was collected in the 2007 household survey only, and so we used simple difference method to analyze the difference in the mean consumption expenditure per capita between the NAADS participants and non-participation, based on the matched household sample (Table 27). The average value of consumption expenditure per capita was lower among NAADS participants (average of UGX 170,807) than their non-participant counterparts (UGX 182,325), although average value was higher for participants than for non-participants in the early NAADS sub-counties. The differences between the participating and non-participating groups were not statistically significant except in the intermediate NAADS sub-county where the average value was significantly lower for participants by about 35 percent. The overall lower average consumption among the NAADS participants reflects NAADS' strategy of targeting the economically-active poor households in a given community rather than the rich. The higher average consumption value for participants in the early NAADS sub-county shows the potential of the NAADS program in helping to improve households' standard of living over time. Since the differences in consumption expenditure are not based on the panel data, the results cannot be used to attribute them to the NAADS program.

Table 27. Household consumption expenditure per capita across NAADS participants and non-participants, by NAADS cohort (UGX, 2000 prices)

	NAADS participants		NAADS non-participants		*t*-test
	Mean	Standard Error	Mean	Standard Error	
Total	170,807	12,378	182,325	18,646	
Stratum					
Early NAADS sub-county	200,587	18,936	178,020	20,944	
Intermediate NAADS sub-county	121,461	13,449	185,557	38,939	**
Late NAADS sub-county	226,148	60,947	241,035	133,781	

*, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.
Source of data: NAADS-IFPRI 2007 household survey.

Compared to official national statistics, however, the average value of consumption for both NAADS participants and non-participants is much lower than the rural average consumption expenditure per capita of UGX 312,460 (UBOS 2006).[19] This suggests that the NAADS participants and their comparable control group were poorer than the average Ugandan rural consumers, but it again reflects NAADS' strategy of targeting poorer communities in the country, at least during the early stages of implementing the program, which the data used here mostly represents.

5.6.3. Food and nutrition security and overall wellbeing

In the two household surveys, farmers were asked to report their perception of how their wealth level, food and nutrition security, ability to meet basic needs, and overall wellbeing had changed (increased, not changed or worsened) between 2000 and 2004 and between 2004 and 2007. We used the simple difference method to analyze differences between the NAADS participants and non-participants in the proportions of households reporting each category of change, based on the panel data of the matched household sample. The results presented in Table 28 show that significantly larger proportions of NAADS participants than non-participants perceived that their situation had improved, while larger proportions of the non-participants than participants perceived that their situation had not changed or it had worsened.

Table 28. Perception of changes in welfare and food and nutrition security across NAADS participants and non-participants (proportion of households)

	Improved		Not changed		Worsened	
	2000-2004	2004-2007	2000-2004	2004-2007	2000-2004	2004-2007
Average wealth level						
Participants	0.51	0.58	0.15	0.14	0.34	0.27
Non-participants	0.41	0.44	0.18	0.20	0.41	0.37
t-test	**	***				**
Access to adequate food						
Participants	0.44	0.54	0.14	0.24	0.42	0.21
Non-participants	0.36	0.38	0.16	0.31	0.48	0.31
t-test		***				**
Nutritional quality of food						
Participants	0.47	0.41	0.25	0.47	0.28	0.12
Non-participants	0.37	0.27	0.26	0.51	0.36	0.22
t-test	**	***			*	***
Ability to meet basic needs						
Participants	n.a.	0.46	n.a.	0.21	n.a.	0.33
Non-participants	n.a.	0.32	n.a.	0.31	n.a.	0.37
t-test		***		**		
Overall welfare/well-being						
Participants	n.a.	0.56	n.a.	0.21	n.a.	0.23
Non-participants	n.a.	0.44	n.a.	0.29	n.a.	0.27
t-test		**		*		

Notes: n.a. means not available since information not collects in the 2004 survey. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.
Source of data: Panel from NAADS-IFPRI 2004 and 2007 household surveys.

[19] The official statistics reported by UBOS was UGX 32,574 (UBOS 2006), which we multiplied by 12 to obtain the annual value. Then, we applied the CPI deflator of 1.251 to obtain the 2000 value.

For example, 41–58 percent of all NAADS participants perceived that their average wealth, access to adequate food, nutritional quality of food, ability to meet basic needs or overall wellbeing had improved between 2000 and 2004 and between 2004 and 2007, compared to 27–44 percent of their non-participant counterparts. The differences in perception between the NAADS participants and non-participants were mostly significant at p=0.05. These results are consistent with the positive impacts of the NAADS program on adoption of improved technologies and agricultural productivity and income, and they suggest the NAADS program has helped farmers to improve their households' standard of living. The overall improvement in average wealth, access to adequate food, nutritional quality of food, ability to meet basic needs or overall wellbeing for both participants and non-participants, especially between 2004 and 2007 is consistent with the increase in the per capita consumption expenditure of Ugandans between 2002/03 and 2005/06 (about 9.5 percent) (UBOS 2006).

5.6.4. Distribution of impacts

To examine the distributional impacts of the NAADS program, we look at the ATT_j associated with agricultural income per capita across several categories, including regional administrations, male versus female headed households, and income terciles. We used the ATT estimated with the matching methods, i.e. covariate matching with nearest 10 neighbors and kernel matching. The detailed results are presented in Table 29. Results associated with the covariate matching method are preferred.

Table 29. Distributional impacts of NAADS on change between 2004 and 2007 in agricultural income per capita (percentage difference between NAADS participants and non-participants)

	NAADS_total		NAADS_direct	
	Covariate matching	Kernel matching	Covariate matching	Kernel matching
Total sample	38.9 ***	40.2 *	49.7 ***	39.2
Region				
Central	117.1 ***	114.4	165.1 ***	176.6
Eastern	-17.1	25.6	23.6	73.0
Northern	-20.9	96.7	-9.5	84.8
Western	64.2 ***	58.2	65.9	40.0
Gender of household head				
Female	53.3 *	-139.3	41.3	75.2
Male	36.7 **	32.4	49.9 ***	29.6
Asset poverty terciles				
Tercile 1 (poor)	105.2 *	119.9	166.7 **	257.5 *
Tercile 2 (middle)	72.8	62.8	20.7	28.5
Tercile 3 (rich)	35.9 **	46.6	39.5 **	41.3

Notes: Numbers in parentheses are standard errors. *, ** and *** means statistical significance at the 10%, 5% and 1% level, respectively.
Source of data: Panel from NAADS-IFPRI 2004 and 2007 household surveys.

Looking at the regional distribution of the impacts shows that the largest impact of the NAADS program has so far occurred in the Central Region, where the per capita income of NAADS participants more than doubled between 2004 and 2007 compared to their non-participant

counterparts. This was followed by the Western Region, where per capita income of NAADS participants grew by nearly 65 percent within the same time period. NAADS participants in the other two regions were associated with a decline in per capita income compared to their non-participant counterparts, although the difference between the two groups was not statistically significant. Official national statistics also show households in the Central and Western Regions as having the highest and second highest rural consumption expenditure, respectively (UBOS 2006). The Western and Central Regions were also associated with the highest and third highest growth rate in rural consumption expenditure, respectively (UBOS 2006). Therefore, our results suggest that the impact of the NAADS program has been more pronounced in the well-off regions. Perhaps, farmers in the more well-off regions are in a better position to acquire the improved technologies and related advisory services being promoted by the NAADS program. This underlies the issue of confoundedness or targeting, where having certain pre-requisites can enhance the impact of an investment program. The Central and Western Regions also have better infrastructure and rural services.

Looking at female- and male-headed households separately, the NAADS program has had more impact on women when looking at the total impacts, but more for men when looking at the direct impacts only. With respect to the total impacts, women participating in the program were associated with 16 percentage points more increase in their average per capita incomes than men participating in the program. Given the statistical insignificance of the estimated impact associated with *NAADS_direct* (Table 29), the above result suggests that female farmers are benefiting more indirectly, e.g. through observing and learning from the TDSs, than directly through access to NAADS grants for acquisition of technologies and related services. It seems then that NAADS is only partially achieving its objective of targeting women, a group that has experienced limited access to agricultural extension in SSA. For example only 7 percent of extension resources is spent on women (Blumberg 1994 cited in Haug 1999). Accordingly, women's access to extension services is lower than men's (e.g.: Adesina et al. 2000; Alawy 1998; Doss 2001; Staudt 1986). Globally, women receive only 2-10 percent of extension contacts and 5 percent of services (FAO 1997).

The distribution of impacts by asset tercile shows that the NAADS program has been more successful at raising income among the poorest households, where the per capita income of those participating in the program more than doubled between 2004 and 2007 compared to their non-participating counterparts. This was followed by the richest group, where per capita income of NAADS participants grew by nearly 36–40 percent within the same time period. Growth in income of NAADS participants in the middle category was not statistically different compared to that of their non-participant counterparts. While the former result suggests that NAADS is achieving its objective of targeting the economically-active poor, the fact that the richest participants also benefited compared to those in the middle underlies the importance of household's capacity to acquire the improved technologies and related advisory services being promoted by the NAADS program.

6. RETURNS TO INVESTMENTS ON NAADS

In this chapter, we analyze the returns to NAADS investments made so far (i.e. up to 2006/07) by estimating the net present value of the benefit-cost ratio. As explained earlier, this can be done at the national level by extrapolating the benefits from the survey data upwards to that level and then comparing it with the total expenditure on the program. However, given that the survey data that were used in the analysis are only representative of the sub-counties that were surveyed, rather than of the districts or the entire nation, we estimate returns to investment made in the surveyed sub-counties only. First, we look at the estimation of the total benefits and how it is distributed over time. This followed by estimation of the costs, the benefit-cost ratio, and then a discussion of the results, limitations of the study, and implications for further research. As before, all monetary amounts are in 2000 value terms.

6.1. NAADS' Benefits in the Surveyed Sub-Counties

To estimate the total benefits of the NAADS program, we used the estimated ATTs on agricultural income per capita. First, we estimated the distribution of the benefits over time by averaging the ATT_j for sub-samples of the discrete number of years since the NAADS program was introduced in the sub-county. Then, the total benefits for each year was calculated by multiplying the average *ATT* for each year by the total number of farmers that are expected to benefit from the NAADS program in that year, which was obtained by multiplying the percentage of survey respondents that directly benefited from the program (i.e. *NAADS_direct*)[20] by the total population of farmers in the sub-county. The percentage of farmers benefiting from NAADS program in each year was assumed constant at 49 (see Table 10). The total number of farmers in the surveyed sub-counties was obtained by using data from the 2002/03 population census (UBOS 2003). First, we used the average of 5305 households per sub-county and 4.9 persons per household, and then we applied the average annual population growth rate of 3.5 percent to get the annual population for each sub-county.

As we used different methods and model specifications to assess the impact on the NAADS program, which yielded different but significant point estimates of ATT on agricultural income per capita, the total benefits are estimated using the ATT range of 42-53 percent to obtain the total benefits associated with the low and high values. The estimated annual benefits are shown in Table 30. To summarize, the total benefit of the NAADS program in the 37 surveyed sub-counties up to the 2006/07 financial year is estimated at UGX 67.1-84.8 billion.

Table 30. NAADS' total benefits in the 37 surveyed sub-counties (2000 UGX, millions)

	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
Low value	6,850	10,971	11,355	11,752	12,522	13,700
High value	8,653	13,858	14,343	14,845	15,817	17,306
Average value	7,752	12,415	12,849	13,299	14,169	15,503

[20] We used the direct beneficiaries (i.e. NAADS_direct) only rather than including the indirect beneficiaries (i.e. NAADS_total), since the estimated impacts associated with the later were not statistically significant.

Source: Authors calculation based on estimated impacts of the NAADS program on agricultural income (Table 25) and expected direct participants of the NAADS program (Table 10) and 2002/03 population census data (UBOS 2003).

6.2. NAADS' Expenditures in Surveyed Sub-Counties

The cost of the NAADS program was based on two sources of data: the NAADS Secretariat on the overall expenditures and the surveyed sub-county offices on their specific expenditures. Based on transfers from the Secretariat to the districts and sub-counties (including contributions made by the districts and sub-counties), Figure 10 shows that direct expenditures on the program in surveyed sub-counties increased consistently over time at about 37 percent per year and amounted to UGX 5.5 billion between 2001/02 and 2006/7 financial years.

As expected, the bulk of these expenditures at the beginning of the program's implementation were on farmer institutional development (e.g. 48 percent in 2001/02) and coordination (27 percent in 2001/02), with relatively little of the expenditures on advisory services and technology development (e.g. 25 percent in 2001/02) and nothing on market development (Figure 11). As the program matured, spending shifted towards advisory and information services and then again towards technology development. In the last financial year for example (i.e. 2006/07), 43 percent was spent on technology development, followed 30 percent on advisory and information services, 11 percent each on farmer institutional development and coordination, and 6 percent on linking farmers to markets (Figure 11).

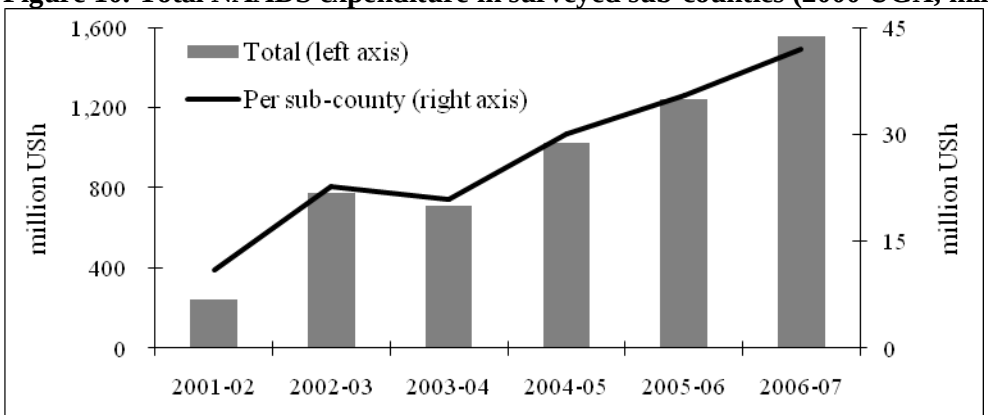
Nearly all of the allocation for technology development was expended on procuring inputs, which amounted to a total of UGX 1.5 billion between 2001/02 and 2006/7 financial years (Figure 12). Spending has tended to favor planting material (accounted for about 46 percent over the entire period), followed by livestock (29 percent), and other inputs and equipment (22 percent). The amount spent on chemical fertilizers was relatively very low and amounted to 3 percent over of the total amount spent on inputs over the 2001/02–2006/07 period.

The above expenditures, however, do not include the amounts spent at the Secretariat and at the district level. They also do not include the opportunity cost of the time of the Community-Based Facilitators (CBFs) in providing advisory services. These amounts need to be imputed. Regarding the amounts spent at the Secretariat and at the district levels, we first isolated the investment or capital expenditures component and applied the straight line depreciation method with zero salvage value to distribute these costs over the life time of the project, which was assumed to be 20 years. Then for each year, we divided the total (i.e. operational and investment) costs proportionally for each sub-county according to the number of sub-counties where the program was implemented at the time.

Regarding the opportunity cost of time of the CBFs in year *t* ($C_{CBF,t}$), we applied the following equation, which was presented earlier:

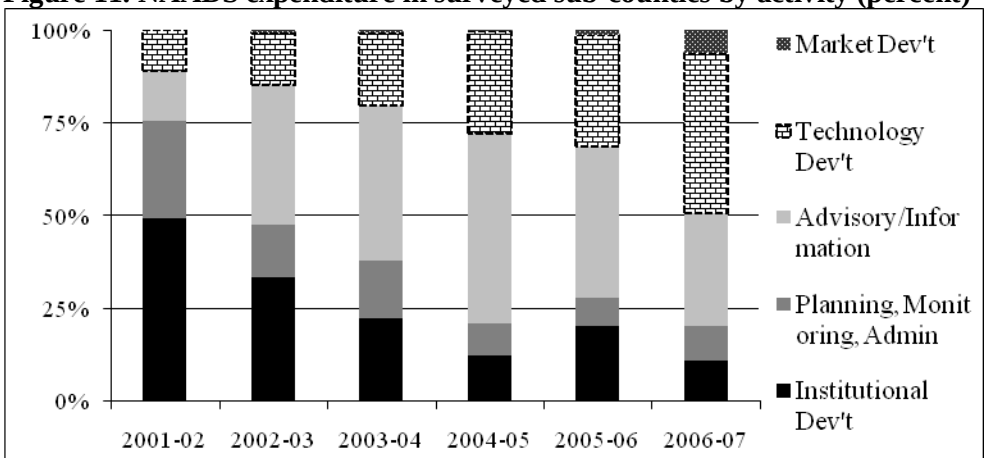
$$C_{CBF,t} = EXT_{CBF,t} * \boldsymbol{h}_t * w_t * n_t$$

Figure 10. Total NAADS expenditure in surveyed sub-counties (2000 UGX, millions)



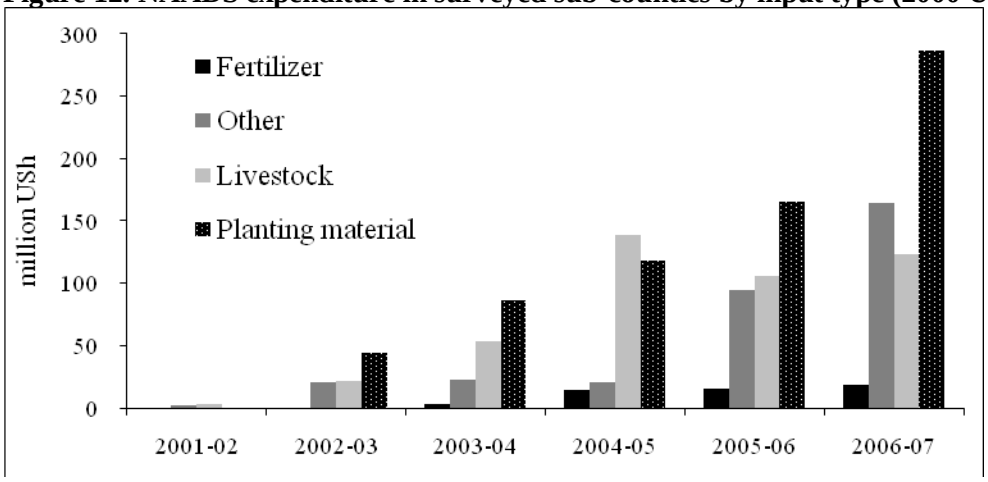
Source: Authors calculation based on data from the NAADS Secretariat and sub-county offices.

Figure 11. NAADS expenditure in surveyed sub-counties by activity (percent)



Source: Authors calculation based on data from the NAADS Secretariat and sub-county offices.

Figure 12. NAADS expenditure in surveyed sub-counties by input type (2000 UGX, millions)



Source: Authors calculation based on data from the NAADS Secretariat and sub-county offices.

Where: EXT_{CBF} is the average number of CBF visits received by a farmer each year, which is obtained from the household survey panel data and was 0.4 in 2004 and 0.5 in 2007; *h* is the average number of hours spent by a CBF in a farmer visitation, which is assumed at 1.5 hours; *w* is the hourly wage rate, which is estimated at UGX 300 in 2000 value terms;[21] and *n* is the number of farmers visited by a CBF, which was obtained by the percentage of the surveyed farmers visited by a CBF multiplied by the population of farmers. The proportion of farmers visited by a CBF each year was obtained by a linear extrapolation of estimates from the household survey data in 2004 and 2007, which were 6 and 7 percent, respectively. The number of farmers in each sub-county was obtained as discussed earlier.

Table 31 shows our estimated total cost of the NAADS program between 2001/02 and 2006/07 fiscal years in the 37 surveyed sub-counties. The total cost over the entire period is estimated at UGX 14.4 billion.

Table 31. NAADS' total cost in the 37 surveyed sub-counties, (2000 UGX, millions)

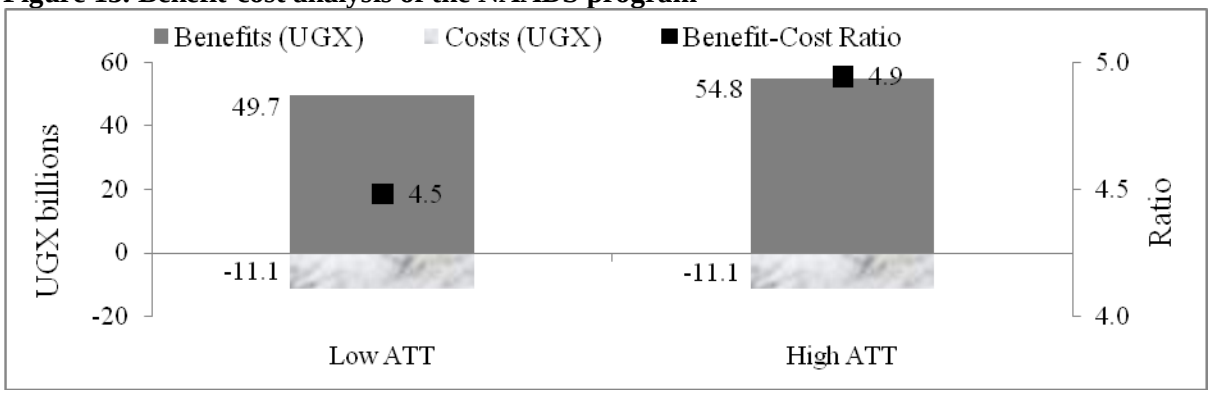
	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
Imputed Secretariat/District	2,864.82	1,687.36	1,619.84	621.81	1,139.48	939.38
Sub Counties	242.25	773.97	709.96	1,025.87	1,243.16	1,556.68
Community-Based Facilitators	0.51	1.01	1.27	1.56	1.94	2.45
Total	**3,107.59**	**2,462.35**	**2,331.07**	**1,649.23**	**2,384.58**	**2,498.51**

Source: Authors calculation based on data from the NAADS Secretariat and sub-county offices.

6.3. Benefit-Cost Analysis in Surveyed Sub-Counties

Based on the above distribution of benefits and costs over time and using an 8.5 percent discount rate, we applied equation (6) to obtain the discounted present values of the benefits and costs shown in Figure 13. The benefit-cost ratio is about 4.5-4.9, corresponding to the lower and higher end values of the range of the estimated benefits, meaning that UGX 1 spent on the NAADS program so far has yielded about UGX 5 in terms of its contribution to agricultural income.

Figure 13. Benefit-cost analysis of the NAADS program

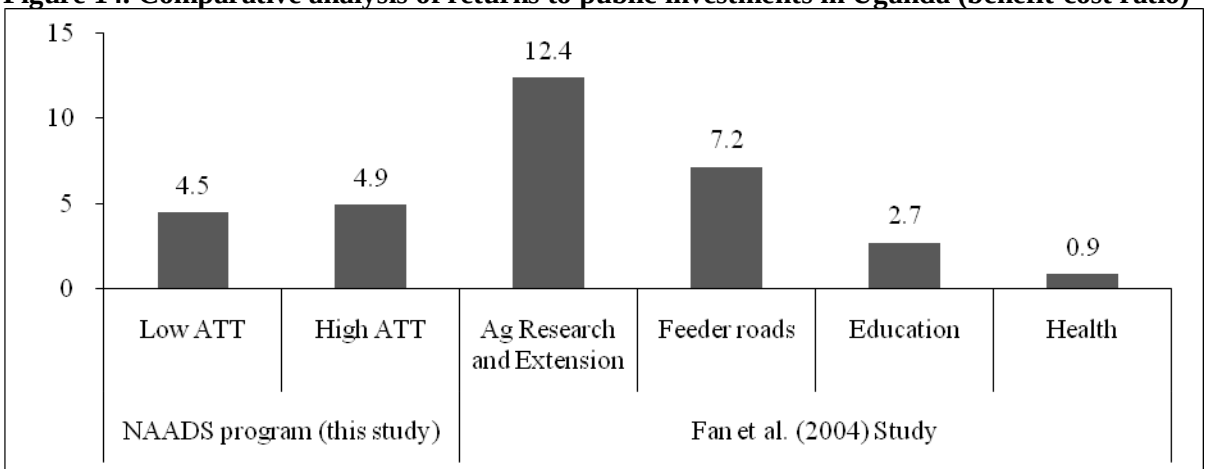


Source: Authors calculation based on estimated benefits (Table 30) and costs (Table 31).

[21] This is based on average hourly rate for causal and agricultural labor in the central region, Masaka and the southwest (Barambah et al. 2007)

Since the NAADS program is a public investment program and there are different types of public investments that contribute to growth and welfare, it useful to compare the above returns to those of other investments. For example, Fan et al. (2004) estimated the agricultural labor productivity (or value of agricultural output per worker) returns to combined agricultural research and extension system prior to the implementation of the PMA and NAADS. Fan et al. (2004) also estimated the agricultural labor productivity returns to investment in other sectors, including road infrastructure, education and health. Although their methodology and data are very different from ours, the comparison is still useful (see Figure 14). The returns to NAADS obtained here are slightly higher than those obtained in the study by Fan et al., although we do not account for the benefits and costs of agricultural research here. We also do not account for the economy-wide effects of wages. The returns to investment in the NAADS program obtained here are higher than those associated with investments in feeder roads, education and health, in terms of their contribution to agricultural labor productivity (Figure 14).

Figure 14. Comparative analysis of returns to public investments in Uganda (benefit-cost ratio)



Accounting for cost of farm inputs and operations and cost of raising public funds

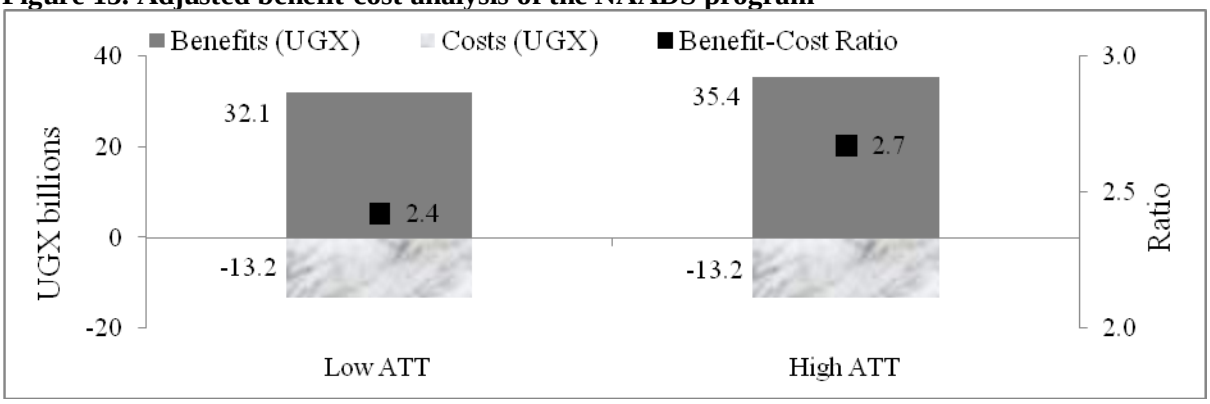
The benefits of the program as estimated above were based on the gross agricultural income per capita, which did not account for the cost of farm inputs and operations. We estimated these costs to account for about 35 percent of the gross income, which was obtained by comparing the 2007 estimated net agricultural income per capita to the estimated gross agricultural income per capita. Therefore, the discounted total benefits were re-estimated to be UGX 32.1-35.4 billion, corresponding to the lower and higher end values of the range of the estimated ATTs on agricultural income per capita.

Public spending necessarily implies raising taxes, now or in the future. However, it is common knowledge that taxation alters society's consumption and production decisions. Hence, society's welfare changes as a result of tax variations. The monetary value of the welfare change per unit of revenue raised (or the deadweight loss) is the marginal cost of public funds. Basically, the

shadow price of a dollar of public revenue is higher than 1 because, in addition to the deadweight loss, the government incurs administrative costs to collect taxes. The deadweight loss (i.e. negative effect on production and consumption) has been estimated to range from 1.05 to 1.37 percent of GDP for several African countries, while the administrative cost of governments to collect taxes has been estimated to range from 1 to 4 percent of total tax collections (Warlters et al. 2005 cited in Herrera 2008). For the NAADS program, the Government of Uganda obtained a development credit from the International Development Agency in the amount thirty five million three hundred thousand Special Drawing Rights (SDR 35,300,000) at the cost of up to 0.05 percent per annum of amount not withdrawn (i.e. commitment charge) and up to 0.075 percent per annum of amount withdrawn (i.e. service charge) (ROU/IDA 2001). The credit is expected to be paid from June 2011 to December 2040, with at least a 1 percent payment of the principal amount up to December 2020 and 2 percent thereafter. To be able to pay back the credit and interest, the government anticipates an increase in its tax and non tax revenues by 0.5 to 1 percent a year from the existing base of 12 percent of GDP (ROU 2001).

Therefore, taking account of the interest payments only (i.e. not accounting for the deadweight loss and administrative cost to collecting taxes), we estimated the additional discounted costs to be UGX 2.4 billion, which together with the reduced benefits brings the benefit-cost ratio to about 2.4-2.7, corresponding to the lower and higher end values of the range of the estimated benefits (see Figure 15).

Figure 15. Adjusted benefit-cost analysis of the NAADS program



Notes: Based on data for 37 surveyed sub-counties. BC1 is based on gross income (see Figure 13) while BC2 is adjusted for cost of farm inputs and operations and interest payment on the loan for the NAADS program.

6.4. Limitations of Returns to Investment Analysis

Although we have tried to capture many important issues in the field of program evaluation in general and of the benefits and costs of the NAADS program in particular to assess the economic returns to the NAADS program, a few issues remain that future research can improve upon. These relate to general equilibrium effects of the program, complementarity (or substitutability) between the program and other different types of public investments, and other benefits of the program.

General equilibrium effects

Scaling out the NAADS program to all parts of the country is very likely to have an effect on relative prices and may require additional taxation to pay back the loan obtained to finance the program. Both effects mitigate the impact of the program, leading to an overestimation of benefits that is based on partial equilibrium analysis, as done in this study. Strengthening the capacity of farmers and service providers also will affect skill composition of the labor force and service providers, which in turn will affect the wage structure and cost of advisory services.

Interactions with different types of public investments

In the mid-term evaluation, Benin et al. (2007) found that there are other factors beside the quality of advisory services that influence technology adoption and agricultural productivity. This suggests the need for complementary progress with respect to implementation of the other pillars of the PMA that address many constraints facing farmers, particularly shortage of capital and credit facilities and lack of profitable agricultural inputs. Although we have controlled for the independent influence of many of these factors by including relevant variables in the regression models, we have not dealt with any complementary or trade-off effects. A typical example is the complementarity between investment in the NAADS program (i.e. advisory services) and investments in agricultural R&D and education. This is because agricultural improved technologies tend to be highly complex, knowledge intensive, and location specific, and so improved technologies that are profitable under local conditions as well as adequate knowledge and skills for their appropriate uptake are required if the NAADS program is to be successful (see e.g. Shultz 1982; van de Walle 1996). Typically, interaction terms among the relevant investment variables can be included in the regression models to capture any complementary or substitution effects. To the extent that complementarity (substitutability) exists, the benefits as measured here would be overestimated (underestimated). Due to the small sample size of our data, interaction terms could not be included in the regressions as doing so can introduce severe multicollinearity, which would then cause the regression parameters to be estimated imprecisely; meaning wrong signs and implausibly large values, among others (Greene 2003).

Other benefits

The NAADS program can be expected to generate a range of other benefits that have not been explicitly considered here or assessed quantitatively. These include the improved human resource skills associated with training and strengthening of local institutional capacity. The program's training on technical and managerial areas that are provided to private service providers, extension staff, subject matter specialists, and research staff will develop improved skills, which would contribute to productivity improvements not only on the farm but off it. Training of village groups, community-based facilitators, farmer contact groups, and farmer fora at the local level will strengthen local institutional capacities and empower farmers to effectively demand advisory services. The improvements in both the human resource skills and institutional capacity will generate benefits when also used in non-agricultural economic and non-economic activities.

7. SUMMARY OF KEY FINDINGS AND RECOMMENDATIONS

Recognizing the importance of a multi-sectoral approach to accelerating growth and reducing mass poverty, the Government of Uganda has since 2000 been implementing the Plan for Modernization of Agriculture (PMA) as a key policy initiative aimed at reducing mass poverty to a level below 28 percent by 2014. The PMA, which is situated within the country's vision of *Prosperity for All* and is supported by the broader *Rural Development Strategy*, has an ambitious agenda of policy and institutional reform across seven pillars, a key one of which is improving delivery of agricultural extension through the National Agricultural Advisory Services (NAADS) program. Since its inception in July 2001, NAADS has devised an innovative extension service delivery approach, that targets the development and use of farmer institutions and in the process empowers them to procure advisory services, manage linkage with marketing partners and conduct demand-driven monitoring and evaluation of the advisory services and their impacts. NAADS was initiated in 2001 in six districts (Arua, Kabale, Kibaale, Mukono, Soroti and Tororo), within which the NAADS program began working in 24 sub-counties. By end of 2006/07 financial year, the program had been extended to 545 sub-counties (about 83.1 percent of the total sub-counties), and is expected to cover the entire country by end of the financial year 2007/08. By the end of the 2006/07 financial year also, UGX 110 billion (in 2000 value terms) had been spent on the program.

Building on the mid-term evaluation of the NAADS program by Benin et al. (2007) and others, the overall objective of this study was to undertake a rigorous end-of-Phase 1 evaluation of the NAADS program to analyze and document the outcomes and the direct and indirect impacts of the program, and assess the return on investment in the program. This was done using data from two rounds of farmer group and household surveys conducted in 2004 and 2007; where 900 households and 120 farmer groups were surveyed in 2004, and 1200 households and 150 farmer groups were surveyed in 2007, in addition to obtaining secondary data on NAADS expenditures and provision of public services in all the surveyed sub-counties. There was a panel of 719 households. The survey was based on a stratified sampling according to the NAADS rollout phases: 1) sub-counties where the NAADS program was first established in 2001/02 referred to as *early NAADS sub-counties*, 2) sub-counties where the NAADS program began in 2002/03 referred to as *intermediate NAADS sub-counties*, 3) sub-counties where the NAADS program began in between 2005 and 2007 referred to as *late NAADS sub-counties*, and 4) sub-counties where there has not been NAADS program, hereafter referred to as *non-NAADS sub-counties*.

Using various quantitative analytical approaches, such as trends, descriptive, double difference, propensity-score matching, and two-stage weighted regression methods, we:

5. Assessed the incidence of rural public services among farming households
6. Estimated the impacts of the program on various indicators associated with the objectives of the program, including:
    g. Empowerment of farmers to organize themselves and demand and manage agricultural advisory services;
    h. Farmers' perception of the availability, delivery and quality of advisory services;

i. Farmers' awareness, incidence of adoption and intensity of adoption of improved technologies and practices;
j. Agricultural productivity;
k. Market participation; and
l. Income, assets, food and nutrition security, and welfare

7. Analyzed and quantified 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;
8. Assessed the return on investment made so far in the program.

Incidence of rural public services on farming households

In general, availability of various rural public services (extension services, input supply shops, markets, roads, schools, health centers, etc.) has improved over time, especially between 2001 and 2007, in terms of presence of physical infrastructure as well as farmers' perceptions of their access to the services. However, availability and access were generally better in the NAADS sub-counties than in the non-NAADS sub-counties. To the extent that these services enhance the impact of the NAADS program, the impact of NAADS is expected to decline as it rolls out to the entire country. Basically, the impacts may tend to be overestimated if differences in availability of services between NAADS-participating and non-participating sub-counties are not adequately controlled for. The results suggest the need of improving rural services in remote areas in order to enhance the returns to NAADS and other investments. For example, one of the weaknesses of the PMA was its failure to strengthen other key rural services such rural financial and marketing services. This has weakened the impact of the NAADS program, especially in the Northern and Eastern regions of Uganda where such services are poor. Notwithstanding their weaknesses, the current efforts through the rural development strategy and prosperity for all to strengthen provision of rural financial and marketing services through cooperatives (MAAIF 2005; GOU 2008) will definitely enhance the impacts of the NAADS program and other rural investments.

Farmer institutional development and empowerment

Overall, we found that the most common areas that farmers had received training included development of group constitution and bye-laws, leadership skills, growth and development, planning, record keeping, and savings mobilization; with more than 70 percent of the groups in NAADS sub-counties reporting positively. Also, more groups were trained in the early NAADS sub-counties than in the other sub-counties where the program started later or had not been implemented at all. These suggest that the NAADS program is gradually helping to strengthen the human resource skills and institutional capacity of farmers that will potentially improve natural resource management, agricultural productivity, marketing, etc. This is substantiated by the finding that majority (about 90 percent) of the farmers found the various areas of training to be very useful or useful; although more groups in the early NAADS sub-counties found the training very useful or useful than those in intermediate NAADS sub-counties. NAADS service providers, compared to others, were rated very high on their methods used in the training and on their performance.

In terms of farmers' participation in farmer group activities, we found increasing performance to be strongly correlated with period of entry into the NAADS program, with newly NAADS-participating groups reporting better performance. Although false farmer expectations of receiving cash funds and inputs rather than knowledge and advice could have played a significant role in weak group activities and poor farmer empowerment in certain areas, the above finding also suggests a shift in interest among the older NAADS-participating groups from basic agronomic and production practices to higher value-chain activities, such as marketing and value addition. Thus, operationalization of NAADS' strategy regarding gradual introduction of activities along the entire value chain is critical. The higher value chain activities such as marketing should be given more attention, especially among the older groups, as it has consistently featured low in the implementation of the program (Benin et al. 2007).

In general, farmers felt an increase in their level of empowerment, especially towards technical public officers. This is very encouraging since technical public officers are well placed to address farmers' agricultural production problems or concerns. However, technical public officers also received the worst performance rating in terms of their response to farmers' requests. While this finding raises concern about the ability to meet farmers' demands, it suggests a weakening of advisory services as the NAADS program rolls out to more districts and sub-counties. Complementary increase in resources to maintain or increase advisory services to those already participating in the program, as well as to new farmers to be taken on board, is therefore critical.

Supply of advisory services

NAADS is an enterprise-based program requiring that farmer groups prioritize their enterprises, which can be crops, livestock, fisheries or beekeeping, or a mix, on which advisory services would be focused. As expected, not all enterprises were promoted by NAADS or demanded by farmers everywhere. The major crops promoted by NAADS (and/or requested by farmers) in terms of the number of sub-counties promoted in, or the number of TDSs established, or the number of farmer groups directly benefiting from the TDSs included banana, groundnuts and rice, followed by vanilla and maize. Regarding livestock and other enterprises, the major ones were goats, poultry and beekeeping, followed by cattle and piggery. Comparing the major crops and livestock enterprises that were promoted by NAADS (and/or requested by farmer), livestock enterprises seemed to be more widely favored.

Decision to participate in the NAADS program

Although the NAADS program is a public investment intervention, farmers have to decide to participate in the program through membership of a NAADS-participating farmer group. Then, together with other groups they demand specific technologies and advisory services associated with their preferred enterprises. We find that the longer the NAADS program has been in a sub-county, the more likely farmers in that sub-county are to directly participate in the program. This means that continued engagement with farmers is critical. One-shot or stop-and-go approaches are not likely to yield any sustained pay-offs. Membership in other organizations, which is a measure of social capital, was also strongly associated with greater likelihood of participation in the NAADS program. This is consistent with the NAADS approach in terms of targeting existing

groups to maximize the payoffs from efforts to build farmers' capacity to demand advisory services. Gender, age, education, and income source were not significant factors in determining group membership, which implies that the NAADS program is targeting all socio-economic groups.

Demand for advisory services and adoption of new enterprises and technologies

We find that NAADS has had significant success in increasing the capacity of farmers to demand improved crop varieties, crop management practices, soil conservation, livestock breeds, post-harvest practices and marketing information. This demonstrates that the NAADS demand-driven approach is working. Participation in the NAADS program, however, seem to have lowered the probability to demand soil fertility and agroforestry practices, suggesting low capacity of farmers to demand these technologies and/or weakness of NAADS to provide them. NAADS spent relatively low resources in conducting demonstrations on soil fertility management practices, compared to, for example, acquiring improved planting material. In order to ensure sustainable productivity, NAADS needs to increase the capacity of farmers to demand soil fertility management practices. For example, it may be necessary in the initial stages of demand-driven approaches to supply soil fertility and agroforestry practices in order to build farmers' capacity to demand them.

Crop and livestock productivity and commercialization of agriculture

Consistent with the positive impact on capacity strengthening, demand for advisory services, and adoption of improved technologies, the NAADS program has had significant impact on crop productivity, with the value of gross crop output per acre having increased by up to 29 percent for those participating directly in the NAADS program more than for their non-participant counterparts. The impact of the NAADS program on livestock productivity is surprising, as the results show that the program has contributed to a decline (about 27-45 percent) in the value of gross livestock output per unit of animal among NAADS participants compared to their non-participant counterparts.

An important area that the NAADS program seeks to address is the low commercialization of agricultural production. We find that NAADS has had a small impact on proportion of agricultural output sold by farmers. The impact of the program is estimated to be up to 6 percent increase in crop sales for the NAADS participants over their non-participant counterparts, and up to 4 percent more sale of total agricultural production. The impact on sale of livestock products is negligible. The NAADS program needs to shift activities away from basic agronomic and production practices towards higher value-chain activities.

Income, consumption expenditure, food and nutrition security, and welfare

NAADS participants were associated with 42-53 percent average increase in their per capita agricultural income compared to their non-participant counterparts. The impact of the program on total agricultural income was more favorable than the income obtained from crops and livestock. This is due to additional substantial income for NAADS participants from high-value agricultural activities such as beekeeping and aquaculture, and demonstrates the effectiveness of

the program in diversifying income and promoting more high-value activities. The results also show that significantly larger proportions of NAADS participants than non-participants perceived that their situation had improved, while larger proportions of the non-participants than participants perceived that their situation had not changed or it had worsened. For example, 41–58 percent of all NAADS participants perceived that their average wealth, access to adequate food, nutritional quality of food, ability to meet basic needs or overall wellbeing had improved between 2000 and 2004 and between 2004 and 2007, compared to 27–44 percent of their non-participant counterparts. These results are consistent with the positive impacts of the NAADS program on adoption of improved technologies and agricultural productivity and income, and they suggest the NAADS program has helped farmers to improve their households' standard of living.

Factors affecting realization of impacts

Several factors significantly influenced farmers' decision to participate in the program, their demand for advisory services, and changes between 2004 and 2007 in adoption of improved technologies and practices, crop and livestock productivity, sale of output, and income. The main factors include gender and age of the household head, education, income sources, land and non-land productive assets, and access to all-weather roads. There are two main implications of this. First, the impacts of the program tend to be overestimated when these factors are not controlled for. Second, these are the factors that should be considered for targeting to maximize payoffs from the program.

Distribution of impacts

Regional distribution of impacts show that the largest impact of the NAADS program has so far occurred in the Central and Western Regions, where the per capita income of NAADS participants rose by 65-165 percent between 2004 and 2007 compared to their non-participant counterparts, suggesting that the impact of the NAADS program has been more pronounced in the well-off regions. The NAADS program has also had more impact women, when looking at the total impact as opposed to the direct impacts, when men have benefitted more. With regards to the total impacts, women participating in the program were associated with 16 percentage points more increase in their average per capita incomes than men participating in the program. This suggests that NAADS is only partially achieving its objective of targeting women, a group that has attracted little resources and experienced limited access to agricultural extension in SSA. The distribution of impacts by asset-endowment tercile shows that the NAADS program has been more successful at raising income among the poorest households, where the per capita income of those participating in the program more than doubled between 2004 and 2007 compared to their non-participating counterparts. This was followed by the richest group, where per capita income of participants grew by nearly 36–40 percent within the same time period. These suggest that NAADS is achieving its objective of targeting the economically-active poor. However, the fact that the richest participants benefited more than those in the middle asset class underlies the importance of household's capacity to acquire the improved technologies and related advisory services being promoted by the NAADS program.

Return on investment

Based on the gross agricultural income per capita, the total benefits of the NAADS program in the 37 NAADS-participating sub-counties that were surveyed was estimated at UGX 49.7-54.8 billion. The total cost was estimated at UGX 14.4 billion, indicating a benefit-cost ratio of about 5. This means that every UGX 1 spent on the NAADS program so far has yielded UGX 5 in terms of its contribution to agricultural income.

On accounting for the cost of agricultural inputs and operations, which were estimated at about 35 percent of the gross income, the discounted total benefits dropped to UGX 32.1-35.4 billion. Similarly, accounting for the interest payments on the loans acquired to finance the program led an additional cost of UGX 2.4 billion (or 16.8 billion total), which together with the reduced benefits reduced the benefit-cost ratio to about 2.5.

Issues for future research

Although the study tried to capture many important issues regarding the benefits and costs of the program to assess the economic returns, a few issues remain that future research can improve upon. These relate to general equilibrium effects, complementarity (or substitutability) of public investments, and other benefits. For example, the scaling out of the NAADS program to all parts of the country is likely to affect relative prices and may require additional taxes to pay back the loan obtained to finance the program. Both effects mitigate the impact of the program, potentially leading to an overestimation of benefits based on partial equilibrium analysis. Similarly, strengthening the capacity of farmers and service providers also will affect the skill composition of the labor force and service providers, which in turn will affect the wage structure and cost of advisory services. Thus, including economic modeling techniques in future analysis will prove useful.

Another issue is the complementarity (or trade-offs) between the NAADS program and other different types of public investments. For example, we would anticipate complementarity between investment in the NAADS program and investments in agricultural R&D and education. This is because agricultural technologies tend to be highly complex, knowledge intensive, and location specific, and so technologies that are profitable under local conditions and knowledge and skills are required for the success of the program. Typically, interaction terms among the relevant investments can be included in the regression model to capture these effects; and to the extent that complementarity (substitutability) exists, the benefits would be overestimated (underestimated). Due to the small sample size of the survey data used in the study, interaction terms could not be included in the regressions as doing so can introduce severe multicollinearity, which would then cause the regression parameters to be estimated imprecisely.

The NAADS program can be expected to generate a range of other benefits that have not been considered here nor assessed quantitatively. These include the improved human resource skills associated with training and strengthening of local institutional capacity. For example, training on technical and managerial areas that are provided to private service providers, extension staff, subject matter specialists, and research staff will develop improved skills, which would contribute to productivity improvements not only on the farm but off it. Training of village groups, community-based facilitators, farmer contact groups, and farmer fora at the local level

will strengthen local institutional capacities and empower farmers to effectively demand advisory services. The improvements in both the human resource skills and institutional capacity will generate benefits when also used in non-agricultural economic and non-economic activities.

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