FCND DP No. 163

FCND DISCUSSION PAPER NO. 163
EPTD DISCUSSION PAPER NO. 112

AN INTEGRATED ECONOMIC AND SOCIAL ANALYSIS TO ASSESS THE IMPACT OF VEGETABLE AND FISHPOND TECHNOLOGIES ON POVERTY IN RURAL BANGLADESH

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October 2003

Abstract

The study examines the poverty reduction implications of the introduction of three different agricultural technologies by government and NGOs in three rural sites across Bangladesh. The first is new vegetable seeds developed by AVRDC and introduced in Saturia to women owning small amounts of land by a local NGO, based on a training and credit dissemination approach. The second is polyculture fish technology developed by the World Fish Center and introduced by a government extension program based on private fishponds operated mostly by men in Mymensingh. The third is the same polyculture fish technology, but introduced through a local NGO in Jessore, based on the arrangement of leased fishponds operated by groups of low income women, supported by training and credit provision.

The study found a number of significant poverty impacts. Among the strongest was in the case of vegetable technology, which is targeted toward women in households with relatively small amounts of land and is a "nonlumpy" technology requiring a very low level of investment, but with substantial returns and positive impacts on female empowerment and child nutritional status. The private fishpond technology was less successful in terms of poverty impact, since only better-off households tend to own ponds. This technology, however, had positive effects on the pond and crop profits of these households. The operation of the group fishpond technology, though a potentially beneficial agricultural program for poor households, was significantly undermined by collective action problems. Relative to women who did not have access to this group-based program, female group members appeared to have more mobility, greater likelihood of working for pay, higher off-farm incomes, and better nutritional status. The group fishpond technology was also found to increase vulnerability in a number of ways, such as through the theft of fish from ponds, or through gendered intrahousehold inequalities in technology-related time burdens and access to markets for, and hence income from, the agricultural outputs.

The study overall showed a higher level of trust for NGOs as opposed to government services, but it also highlighted the variable performance of NGOs. Political dimensions to NGO activity also emerged as important, and are perceived by some sections of the community to affect the dissemination of technologies and extension support services for the technologies.

Quantitative and qualitative data were found to complement each other well in the research across a range of issues. For example, the survey addressed female empowerment adopters by measuring the frequency of women's attendance of meetings, etc., while the focus groups revealed the importance of the nonmonetary exchange of vegetables between households to maintain social networks and reduce vulnerability. There were also gains through the overall use of the sustainable livelihoods framework as a way of sharpening understanding of the different entry points at which technology can affect household well-being and vulnerability.

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Acknowledgments

The economic data used in this paper were originally collected under a grant funded by the United States Agency for International Development, Office of Women in Development, Grant No. FAO-0100-G-00-5020-00, on Strengthening Development Policy through Gender Analysis: An Integrated Multicountry Research Program. Howarth Bouis, Agnes Quisumbing, and Bénédicte de la Brière are acknowledged for their work in designing that survey and collecting those data. Lawrence Haddad, Jere Behrman, Robert Chambers, and Tony Bebbington are thanked for their helpful comments. Ruth Meinzen-Dick is gratefully acknowledged for her support along the way and her assistance with helping us finalize the paper. Thanks go to Data Analysis and Technical Assistance (DATA) of Dhaka, Bangladesh, for its work in collecting the economic data. An immeasurable debt is owed to the local survey respondents and focus group participants for their willingness to give their time and share details of their lives.

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1. Introduction

Background

Green Revolution technology has contributed to increased agricultural production, but questions have been raised concerning its exact impact on poverty reduction. This case study seeks to integrate economic and social analysis to assess the impact of new vegetable and fish technologies on poverty and vulnerability in Bangladesh. This study is distinctive in that it draws on data that include both traditional economic measures (e.g., household income sources, profits from farm production, nutrition outcomes, food expenditures) and those that are more social in nature (e.g., social connectedness, empowerment, institutional structures). Drawing on both types of information provides a more integrated and holistic view of rural livelihoods.

The research combines data from census and survey material collected in 1996-97 with focus group discussions and semistructured interviewing conducted in 2001. Elements of the Department for International Development (DfID) sustainable livelihoods (SL) framework were used to help frame specific research questions, devise a qualitative data collection strategy that would generate new insights into the existing data, and orient the collection of supplementary data on a range of new issues, such as technology dissemination pathways and the wider social context.

Country Context

Poverty reduction is the central policy challenge for Bangladesh, one of the poorest countries in the world. According to the World Bank (1999), around 36 percent of the population were "very poor" and 53 percent "poor" in 1995–96. While this compares favorably with rates of 40 percent and 57 percent, respectively, in 1983–84, other sources, such as the *Human Development Report* (UNDP 1999), point out that poverty rates in the mid-1990s were higher than they were a decade earlier.

There is a strong gender dimension to poverty in Bangladesh. The distribution of consumption within households favors men. Of 43 studies reviewed by Haddad et al. (1996), pro-male bias in nutrient allocations appears to be most prevalent in South Asia[1]; boys in this region are also more favored in the distribution of nonfood health inputs, such as healthcare.[2] Furthermore, this is the only region of the world where girls have higher child mortality rates than boys. Rural households headed by women are more likely to be among the poorest. Even with Food for Education and other incentive programs for female education, girls still have lower educational attainment than boys.

Rural poverty is still a pervasive problem in Bangladesh. Recent reductions in poverty in the 1990s were larger in urban than in rural areas (World Bank 1996). Ninety-three percent of very poor households and 89 percent of poor households are in rural areas. Rural poor employed in the nonfarm sector tend to be better-off than those whose primary employment is in the farm sector. This implies that the promotion of off-farm income sources—such as fisheries, livestock, and forestry—constitute a potentially attractive policy option for addressing rural poverty (World Bank 1999).

Previous Research

This study follows on earlier research undertaken by the International Food Policy Research Institute (IFPRI) and its partners in Bangladesh. Data were collected in 1996-97 to examine the effects of the adoption of vegetable and fishpond management technologies on household resource allocation, incomes, and nutrition. Much of the data (e.g., on activities and earnings) was also collected for individuals within households, therefore allowing analysis of gender-related issues within households.

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[1] One careful study asserts that men both receive more nutrients than women and expend more energy (i.e., they are nutritionally taxed more than women) (Pitt, Rosenzweig, and Hassan 1990). This explanation still does not account, however, for the pro-male bias found in intrahousehold distributions of nutrients for children.

[2] Besides Haddad et al. (1996), see Filmer, King, and Pritichett (1998), Mitra et al. (1997), and Mitra et al. (1994).

Households were surveyed in three sites where NGOs were active in disseminating technologies developed by international agricultural research institutions. These sites were Saturia *thana*, Manikganj district (referred to below as Saturia), Gaffargaon *thana*, Mymensingh district, and Pakundia and Kishoreganj Sadar *thanas*, Kishoreganj district (referred to below collectively as Mymensingh), and Jessore Sadar *thana*, Jessore district (referred to below as Jessore). The technologies and the modes by which they were disseminated differ by site, as indicated in Table 1.

Table 1—Study sites, technologies, and approaches

Site	Saturia (5 cases, 5 comparison villages)	Mymensingh (14 cases, 7 comparison villages)	Jessore (8 cases, 8 comparison villages)
Community characteristics	Less than two hours northwest of Dhaka; some access to Dhaka markets; lots of NGO activity; low-lying flood-prone area	Four to five hours north of Dhaka; remote and socially conservative; little NGO activity; not flood-prone; some water shortages in dry season	Close to western border with India; less socially conservative but politically volatile
Agricultural technology	Privately-grown vegetables	Privately-operated polyculture fishponds	Group-operated polyculture fishponds
Institution originating technology	AVRDC[a]	ICLARM[b]	ICLARM[b]
Dissemination approach	Training and credit to all adopters	Training to all adopters; credit to poor adopters	Training to some members of each adopter group; credit to all group members
Type of disseminating institution	Small local NGO	Government ministry extension program	Medium-size local NGO
Target group	Women NGO members in households with marginal land holdings	Individual or joint pond owners	Poor women, NGO members, predominately landless

[a] The Asian Research and Development Center.
[b] The International Center for Living Aquatic Resources Management.

Vegetable Intervention

In Saturia, credit and training in small-scale vegetable technology is provided to women who grow vegetables on small plots on or near the household compound. The vegetable varieties were initially developed at the Asian Vegetable Research and Development Center (AVRDC), based in Taiwan, and then adapted to Bangladesh

conditions at the Bangladesh Agricultural Research Institute (BARI). The vegetables were introduced through the small NGO Gono Kallayan Trust (GKT). GKT has been operating in Saturia since 1987. In March 1994, GKT added vegetable production using AVRDC/BARI seeds to their portfolio of income-generating programs. Selected GKT extension agents have received training at AVRDC sites outside of Bangladesh. The improved vegetables introduced, include tomato, okra, Indian spinach (*pui shak*), red amaranth (*lal shak*), radish, eggplant, amaranth (*data*), *kangkong* (*kalmi shak*), mung bean, and sweet gourd.

Fish Intervention

The International Center for Living Aquatic Resource Management (ICLARM—now known as World Fish Center), with headquarters in the Philippines, has been providing technical advice to the Fisheries Research Institute (FRI) in Mymensingh since 1988 in regard to polyculture fish production and other fish culture technologies. Seven fish species are being promoted: silver fish, carp (*katla*), *rohu* (*rui*), *mrigel*, mirror carp, *sharputi*, grass carp; blackfish (*kalibouch*), shrimp, and tilapia are also cultivated.

1. In Mymensingh, polyculture fish production is undertaken in privately held, single-owner fishponds. The Mymensingh Aquaculture Extension Project (MAEP) has been operating since July 1990 and is jointly implemented through MAEP extension agents and Ministry of Fisheries extension agents. They provide training to better-off households and training with credit to poorer households. The intervention is directed at both men and women, but men more often than women.
2. In Jessore, the NGO Banchte Shekha arranged long-term leases of ponds, which are managed by groups of women who receive credit and training in polyculture fish production methods. Banchte Shekha extension agents have received training

from both ICLARM and FRI personnel in pond management for polyculture fish production since 1993.

Table 2 shows results of a census of households in each site on the extent of adoption of the target technology just before the household surveys began. While the percentages are not negligible, the time experienced using the technologies was short when the survey began in both the vegetable and the group fishpond sites. They had only been available to the disseminating institutions for two to three years in these sites; thus, experience for any particular adopter would have been for an even shorter time.

Table 2—Study sites and extent of adoption

Site:	Saturia	Mymensingh	Jessore
Technology	**Vegetables**	**Private ponds**	**Group ponds**
Adopters as percent of households in all villages	18	29	8
Adopters as percent of households in technology villages	40	50	16
Elapsed time between introduction of technology and beginning of household survey (years)	2	6	3

The household survey collected data in three sites at four different times and covered one complete agricultural cycle in 1996/1997. The study design included two village types in each site:

1. "A" villages were those where the improved agricultural technology had already been introduced by the disseminating institution.
2. "B" villages were those where the technology had not yet been introduced but where the disseminating institution would eventually disseminate it. In both types of villages, the disseminating institution delivered all the same other services (mainly microfinance). It should also be noted that households in B villages undertook most of the same types of agricultural activities as in A villages, but without the improved technologies.

While the interventions were not randomized to villages, a comparison of village characteristics (shown in Appendix Table 6) indicates very few differences between A

and B villages in infrastructure and access to services. This reduces the likelihood that findings will be biased by the possibility that the technologies were disseminated purposively (i.e., to those deemed to need it most or those deemed more likely to succeed).

The household sampling methodology was to undertake cross-sectional comparisons of adopter and likely-adopter households—with differences in resource allocation behavior and various health and nutrition outcomes between the two groups, indicating the impact of adoption. Such a quasi-experimental design requires careful selection of B households: they should have similar physical capital (land, buildings, livestock), human capital (education, experience), and other difficult-to-observe characteristics (risk aversion, diligence). In case villages, two types of households were selected: those adopting the technology ("A" or "adopter" households), and those not adopting ("C1" or "other" households). In comparison villages, two types of households were selected: those that intend to adopt the technology when introduced and that have similar characteristics to adopter households in case villages ("B" or "likely-adopter" households), and those that do not intend to adopt ("C2" or "other" households). The selection process for A and B households for each site involved undertaking a census of all households in A and B villages. In B villages, households were divided based on answers recorded in the census surveys into two groups—those likely to adopt (all NGO members likely to adopt) and those "not likely to adopt" (non-NGO members plus NGO members not likely to adopt). B households were randomly selected from the first group and C2 households from the second group. Site-specific conditions required unique sample selection methodologies in each case; the complete sampling methodology is described in IFPRI (1998).

This sampling scheme resulted in four household types:

1. Adopter (A) households in case villages: access to technology and adopt;
2. Other (C1) households in case villages: access to technology but do not adopt;

3. Likely-adopter (B) households in comparison villages: no access to technology but wish to adopt;
4. Other (C2) households in comparison villages: no access to technology and do not wish to adopt.

In each of the three study sites, a stratified, choice-based sampling scheme was employed, so that there are 330 households per site:

Adopter (A) households in case villages	110
Other (C1) households in case villages	55
Likely-adopter (B) households in comparison villages	110
Other (C2) households in comparison villages	55
Total households	330

Sampling weights were calculated to take into account each household's probability of being selected for the survey.[3]

For each type of household, the study collected detailed information on production and other income earning activities by individual family members; expenditure on various food, health, and other items; food and nutrient intakes by individual family members; and time allocation patterns and health and nutritional status of individual family members (Table 3). Four surveys of 955 households were conducted at four-month intervals beginning in June 1996. Survey data were supplemented with qualitative research undertaken between survey Rounds 3 and 4 on factors affecting intrahousehold bargaining power. Insights from the qualitative analysis fed into formulation of questions in the last survey round on dowry, assets brought to marriage, and bargaining power in later rounds of the survey.

The richness of the existing data and the variety of agricultural technologies and dissemination strategies provide an excellent base for further study—supplemented by additional qualitative data collection—of the linkages between agricultural production,

[3] Site-specific details of the sampling methodology are available upon request from www.ifpri.org.

livelihood strategies, and a variety of outcomes, including income, nutritional status, vulnerability to shocks, and empowerment of women.

Table 3—Topics covered by survey questionnaires

Topics	Explanation
General household information	Demographics, education, migration
Parcels of land	Ownership, tenure relations
Agricultural production	Steps in production, record input use, output, postharvest processing, disposition of output including revenues from sales, loans, past production history
Agricultural wage labor by family member	By crop, by task
Other sources of income by family member	Nonagricultural employment and transfers
Backyard livestock and vegetable production	Livestock, fruits, vegetables
Asset ownership by family member, dowry, inheritance	History of assets at marriage, current assets
Women's autonomy, mobility, decisionmaking	
Credit use	
Food expenditures	One-month recall
Nonfood expenditures	Four-month recall
Source of water/food preparation/preschool feeding practices	
Reproductive history	
Health services/nutritional knowledge	
Time allocation of head male and female and children under 10 years of age	24-hour recall
Anthropometrics and recent morbidity	Two-week recall
Individual food intake	24-hour recall
Blood analysis; clinical signs of micronutrient malnutrition	
Chronic illness history; use of health infrastructure	

Previous analysis of the survey data (IFPRI 1998) revealed that although vegetables and fishpond production both gave higher rates of return than rice production, agriculture related to the production of high-yielding varieties of rice, rearing of livestock, and off-farm activities were larger sources of income than vegetable or fishpond production. Vegetable production (both AVRDC-target and other vegetables) in adopter and likely-adopter households in Saturia contributed only 2.5 percent and 2.1 percent, respectively, of total household income. The marginal effect of adoption of

AVRDC-improved seeds as compared with other improved and local seeds would seem almost certainly to be less than 1 percent of total household income. In Mymensingh, fishpond production accounts for 9.9 percent and 5.4 percent of total household income in adopter and likely-adopter households, respectively. The difference between the two figures, 4.5 percent of income, represents a rough estimate of the marginal effect of applying the polyculture management technology to existing fishponds. In Jessore, only five of nine group ponds surveyed were operated as intended under the Banchte Shekha program. In two of the four cases of nonoperation, excavation of ponds was not undertaken or excavation was inadequate. Two groups leased out their ponds as a consequence of intragroup disagreements on how to operate the pond and share the output. Cash profit per hectare over the 16 months of the surveys for the five group-operated ponds was about Tk 17,500 (marginally better than B household fishpond profits in Mymensingh). However, average cash profit per month per group member for the five group operated ponds was estimated to be only Taka 16 per month, a modest sum due to the large size of the groups. This was, however, income earned and controlled by the women and not their husbands.

These findings raise the question of why there was not more impact or greater incorporation of the technologies. The answer requires an analysis of the system into which these technologies are introduced, and how the agricultural technologies fit into overall livelihood portfolios, especially of poor households. In particular: Are the new technologies riskier? Do they increase the vulnerability of households? Does the additional labor the technologies require conflict with the pattern of other livelihood activities?

2. Research Questions

The SL framework was used in the study to help organize the main research questions. It was applied as a means of broadening the understanding of poverty and drawing together the various perspectives of social and economic analysis to undertake a

broader poverty impact assessment. Given the overall concern to understand the effects of technology on poverty, and the factors structuring these effects, the research therefore focused on the following questions:

- How do we understand the overall vulnerability context, and what is the relationship between adoption of the new technology and household vulnerability?
- What is the relationship between access to assets, technology adoption, and livelihood strategies? What are the asset constraints on adoption?
- What are the transforming effects of intervening organizations and institutions? How do the dissemination approaches of the NGOs and public-sector agencies involved affect livelihood strategies?
- How are decisions taken within households around choices of livelihood strategies, and how do the agricultural technologies fit with these strategies?
- What outcomes can be measured to detect the direct and indirect effects of technology adoption on adopting and nonadopting households?

Vulnerability Context

The SL framework begins with analysis of the context in which individuals and households act, particularly the physical and socioeconomic factors that affect vulnerability. As noted by Gordon and Spicker (1999, 142), "…vulnerability is not synonymous with poverty but means defencelessness, insecurity and exposure to risk, shocks and stress."

In rural Bangladesh, poverty is pervasive and associated with high vulnerability. A number of factors influence the vulnerability of households in our study sites. These include features of the natural environment (lowland flooding and seasonal water shortages), lack of access to existing natural resources because of poverty or social isolation, lack of availability of the agricultural technologies and the inputs to effectively use them; food shortages during the lean months of the year coupled with already fragile

nutritional status, lack of access to insurance mechanisms due to weak social networks or lack of physical assets to use as collateral (or for liquidation), and lack of decisionmaking power among females.

These factors influence whether and which agricultural technologies are used. In particular, new technologies may be perceived to be so risky as to increase the vulnerability of already at-risk households, or the risks covary with fluctuations with other livelihood sources. Adoption may also influence the vulnerability situation of households by changing the assets they control. Successful adoption of the technology may increase physical and financial assets, so that food and livelihood security are enhanced. Other types of assets could also be affected. For example, increased human and social capital may be an outcome of technical training and group involvement that delivery of the interventions often entails. Less successful adoption could result in loss of physical or financial assets, and even negative social capital, if conflicts arise in the delivery or application of the technology. The introduction and use of technologies may affect vulnerability by changing the transforming structures and processes that influence access to various assets and livelihood strategies.

Assets and Technology Choice

The SL framework pays particular attention to a wide range of assets, including natural, human, financial, physical, and social capital. The asset situation of households influences adoption and choice of technologies by changing access to resources. If the poor lack the ability to obtain the inputs required to use a technology, it is unlikely they will adopt it. Direct ownership of assets such as land and agricultural equipment is a key component; however, other types of assets that one does not necessarily own may bolster access to needed inputs. Membership of poor women in an NGO that arranges leases of fishponds, and women organizing into groups to manage these fishponds, are each examples of social assets influencing technology adoption. The research investigated how various assets influence adoption of the different technologies.

Transforming Structures

Research and extension systems that have inadequate information flows, adverse (e.g., top down, nonparticipatory) incentive structures and overly complex organizational structures can thwart the effective design and implementation of even technically sound interventions. In this study we will investigate the effectiveness of alternative pathways of dissemination (government, private sector, NGOs, farmer-to-farmer, and other informal mechanisms) in reaching the poorest households. In particular, are NGOs more effective than others in service delivery?

We also investigate how well programs are targeted. For example, did the strategy of organizing fishpond groups reach the poor more effectively than targeting households with sole ownership of fishponds? Particular attention is given to the role of gender relations in the adoption of technology, and the effect of gender on the impact of the program.

Other "transforming structures," such as class and caste relations, market organization, and governance, are also relevant, but they are not analyzed in detail here. Our focus is rather on those structures more immediately subject to the influence of external agents.

How Technologies Fit into Livelihood Strategies

Analysis of the household survey data revealed that although vegetables and fishpond production both gave greater income returns than rice production, off-farm activities and production of high-yielding varieties of rice and livestock were more important sources of income than vegetable or fishpond production. This raises questions about how the different agricultural technologies fit into the overall livelihood portfolio, especially of poor households. In particular, do patterns of time allocation shift and conflict with other activities? What are the gender implications of such shifts? What do households give up or gain by adopting the technologies?

Outcomes

We investigate a series of outcomes that adoption of the technology could influence. First, the household survey data are used to compare adopting households living in case villages with likely-adopter households residing in comparison villages. Specifically, we examine differences in income, consumption, nutritional status, and empowerment of women. A second approach will be to use the qualitative data gathered during discussions that took place within the context of "defined" focus groups in 2001. Information on household background characteristics from the original survey was used to recruit particular types of individuals to participate in these focus groups. Using this method for focus group recruitment enables us to attribute particular qualitative information to individuals from particular types of households.

How adoption of the technologies can have indirect influences on outcomes for both adopting and nonadopting households is an important question. In examining the survey data, we do not expect to find many indirect affects for the following reasons:

- The prevalence of adoption and length of experience with applying the technologies in the case villages was still rather low at the time of the household surveys;
- Even for adopting households, the contribution of the technologies to their overall income portfolio was quite small; however, the focus groups provide more opportunity to probe for indirect affects of the technology, since they were conducted several years after the household surveys.

3. Methodology

This research combines an existing quantitative study with the collection of new qualitative data in the three study sites. We found that the existing household survey data could only go so far on certain issues, creating a need to follow up with more qualitative data collection.

Methodology for Further Analysis of the Existing Household Survey Data

Several sets of issues were examined using the existing survey data:

1. *Well-being categories of survey households*. Well-being categories are constructed based on criteria identified in the Bangladesh Participatory Poverty Assessment (PPA) prepared by the World Bank's NGO Working Group. Using variables in the survey data shown to be important well-being indicators in the World Bank PPA, survey households are classified by well-being category. These classifications served as the basis for selecting households to participate in focus group discussions (described in more detail below).
2. *Effects of assets and technology adoption*.
3. *Range of household income sources*.
4. *Technologies' association with and impact on*
    a. Total household expenditure,
    b. Household income,
    c. Empowerment of women,
    d. Child nutritional status outcomes.

The methodologies for measuring the technologies' association with and impact on livelihood outcomes entail means comparison tests and multivariate regressions to control for the possibility of endogenous program placement. The means comparisons take advantage of the unique sampling design of the 1996–97 household survey. The survey was designed so that households in villages with the technology (*A* villages) and villages pending the technology (*B* villages) were both interviewed. In villages with the technology, there are data from adopting and nonadopting households, while in villages pending the technology, there are data from likely- and nonlikely-adopters. If it is the case that (1) villages that received the technology first were not chosen purposefully (i.e., villages that were closer to the NGO office, where the technology was more likely to succeed, or where it was more highly demanded were *not* chosen first), and (2) adopter and likely-adopter households have statistically similar background characteristics, a

comparison of mean differences in livelihood outcomes for these two types of households is a valid method for assessing the impacts of adoption of the technology. However, if either (1) technology-recipient and technology-pending villages or (2) adopter and likely-adopter households differ, then econometric methods that control for "getting the technology" at the village level and "using the technology" at the household level will need to be utilized so that valid assessments of technology impact can be made. These issues are explored in more depth below.

Methodology for Supplementing New Qualitative Data Collection With Existing Quantitative Data

Because the original study did not focus on the broader concept of poverty or livelihood strategies, the existing data are supplemented using data collection that is both qualitative and participatory. We also make use of selected participatory rural appraisal (PRA) techniques. For example, at the time the survey was done, women adopting the new vegetable technologies were reporting that they were working the same number of hours as previously. Did this mean that vegetables required little additional labor input, or did it mean that some other kind of activity was being displaced? There were also issues that were clearly important but could not be addressed with the quantitative data in hand. For example, the importance given in the SL framework to transforming institutions and structures generated the need to record the views of local people on local services. A particular institutional process on which we needed more information, given the context of the study, was the issue of dissemination pathways, such as the question of the effectiveness of NGOs versus government agencies as technology providers.

The qualitative data collection employed focus groups as the main approach, supplemented by some limited semistructured interviewing and the selective use of certain PRA techniques—chiefly those of seasonality mapping and group-based ranking of priorities. Some researchers view qualitative and PRA as the same; however, for us the PRA techniques yielded both quantitative and qualitative data, as in the case of ranking exercises.

A pretest was organized in Saturia in January 2001, in which one focus group discussion was held. This provided an opportunity to refine the questions further and to train the fieldwork team.

Working with the Sustainable Livelihoods Framework

The main strength of the SL framework is that it allows systematic analysis—from the perspective of low-income households—of the range of social and economic forces affecting how members pursue livelihood improvements. By showing how different kinds of households actively deploy different types of assets in their efforts to reduce vulnerability, and at the same time exploring the ways in which households are both helped and constrained by their environments, the SL framework provides a means to analyze livelihoods in terms of process. It also broadens understanding of poverty and vulnerability beyond issues that are viewed as more strictly economic.

However, there are also certain limitations to the SL framework:

- Its conceptual inclusiveness and complexity can make it difficult to operationalize, particularly at the level of practice;
- Understanding power relations precisely remains difficult within this framework (and many others);
- Linking the global and the local in understanding how wider polices and economic forces—such as export policies—can affect household-level strategies remains a challenge (Kanji and Barrientos 2002).

The open-ended nature of the SL framework meant that clear lines had to be drawn around the types of data we would collect and the level at which we would collect them. As described below, we assessed the elements of the SL framework we could address using the information already available in the survey data. The types of information missing were mainly on the vulnerability environment and process and institutional factors. The data collected in the focus groups addressed how the

agricultural technologies affected vulnerability, fit into livelihood strategies, and affected selected livelihood outcomes. We did not look at how the technologies affected livelihood assets or transforming structures and processes because the timeframe of the study was not long or broad enough to investigate these.

Drawing on the recent World Bank NGO Working Group Participatory Poverty Study (PPA) and other related studies, such as the Poverty Alleviation Through Rice Research Assistance (PETRRA) study, we developed three categories of households for comparative qualitative data collection. We used two categories of the poor, which we will term, for the sake of simplicity, "poor" (i.e., the category termed "social poor" by the PPA) and "very poor" (which are those people termed "helpless poor" and "bottom poor" in the PPA). We have also included a single "nonpoor" category (those termed as "rich" and "middle" in the PPA) in the study so that we can examine the position and perspectives of better-off households for a comparison with those that are poor. Characteristics of households in these categories are given in Appendix Table 7. Since the household survey was choice-based and designed to oversample technology adopters and likely-adopters, the profiles of sample households in each site reflect site-specific targeting priorities and differences in livelihood assets needed to adopt the different technologies offered. Hence, households in the group fishpond site of Jessore are more likely to be poor, while those in the private fishpond site of Mymensingh are less poor.

What New Data Were Needed?

As well as the problem of the SL framework's open-ended nature, there was the additional challenge that the framework needed to be grafted onto an existing quantitative study. We took the view that this represented an opportunity rather than a constraint. The combination of an existing quantitative study and the conceptual insights generated by the SL framework provided the means to generate a set of new research questions (to both supplement and complement the quantitative data) that could be addressed through further qualitative research. Table 4 illustrates the ways in which different types of data

and data collection methods addressed the research questions. This provided a framework in which the integration of new qualitative data and existing and new quantitative data could take place.

Table 4—Matching data sources to research questions

Vulnerability	Assets	Strategies	Dissemination pathways	Outcomes
Qualitative (focus groups)	Qualitative	**Qualitative (focus groups)**	**Qualitative (mainly semistructured interviewing)**	**Qualitative (in terms of people's perceptions drawing on PRA)**
Quantitative	**Quantitative (strong survey data)**	Quantitative	–	**Quantitative (strong income and nutrition data)**

Note: bold type indicates strong data, in terms of the relative strengths of quantitative and qualitative data methods in relation to livelihoods.

In each site, three sample villages were drawn for further study. One was chosen randomly from among remote villages as far from the main road system as possible. A second was chosen randomly from among accessible villages, but close to the road with good communications. The third one was randomly selected from the "middle ground." This sample allowed us to compare villages with different levels of infrastructure, information, and market access. The focus groups were held in the case villages (where adoption of technology will be relatively advanced) but not in the comparison villages, where conditions are more or less similar, but where adoption is not yet common.[4]

Each focus group consisted of 6–10 people, and each contained a uniform group structured by socioeconomic category and gender. Households that had participated in the survey and been classified by well-being category were contacted. Their members and members from similar types of households in well-being status were invited to participate in a gender-specific focus group discussion. There were six types of focus groups in each village studied, as indicated in Table 5, for a total of 54 focus groups (3 sites x 3 "technology" villages per site x 6 focus groups per village).

[4] Unfortunately, we could not explore when and to what extent the technologies had in fact been disseminated in comparison villages after the survey. Without a better handle on those factors, it seemed difficult to be able to study *B* villages; hence focus groups were done only in case villages.

Table 5—Focus group categories for each village

Socioeconomic category	1	2	3
Male	Nonpoor	Poor	Very poor
Female	Nonpoor	Poor	Very poor

The approach was generally successful, although fieldwork took longer than expected due to the problem of *hartal* (a general political strike) stoppages. There was also a variation in research accessibility across the three districts, with Mymensingh being the most socially conservative.

There were several important methodological and practical lessons to be learned from the research experience. The first was that we underestimated the logistical complexity of convening focus groups of this kind, where different categories of often busy people in frequently remote village locations had to be convened. Keeping a focus group discussion within the broad range of issues we had targeted was challenging for organizers, especially when such discussions sometimes attracted interest from other villagers and passersby. It was also complicated by the reliance on local consultants to identify and convene the groups who were better acquainted with administering quantitative data collection than with the requirements of this kind of qualitative research. A tendency among some of the research partners to simply equate qualitative research with PRA was a complication in the qualitative research process. We were interested in participatory approaches to all kinds of data collection in the study, but we also wanted to combine as innovatively as possible certain PRA skills with more formal methods.

This study, in part built on ongoing research work, and the addition of new agendas and activities, inevitably generated problems that might have been avoided if the study had been conceived in a more unitary way. For example, there was a time lag between the original quantitative data collection work and the design and implementation of focus groups and semistructured interview work. In the case of Mymensingh and Jessore, the lag was four years. This meant that we were unable to examine in detail the changes that may have been implemented by ICLARM in other areas, based on lessons learned from some of our cases.

4. Findings on Vulnerability Context

Qualitative Findings

The qualitative data helped reveal both material and nonmaterial aspects of vulnerability. The focus groups highlighted the importance of a range of wider aspects of vulnerability in addition to the obvious lack of material assets such as land or cash, or vulnerability to fluctuating markets. These include

- female dependence on male household members or subordination (e.g., for sale of products they have produced; or refusal to allow participation in fish production training);
- lack of technical knowledge about vegetable or fish cultivation, creating perceptions of high risk or disappointing yields;
- law and order problems (e.g., threats of violence to minority households at times of social tension, which can lead to forced sale of land; theft of fish from ponds; or malpractice by officials, staff, or group leaders);
- low levels of trust in relation to a government or NGO service (sometimes after evidence of malpractice) or in relation to fellows (as in the case of some of the fisheries groups); and
- lack of access to justice (the nonpoor may forcibly prevent the poor from taking part in certain activities, or they may take over profitable activities).

There was a wide variation in the general vulnerability context among the three study sites. Saturia is the poorest overall of the three areas, despite being closest to Dhaka. Mymensingh is relatively well off, with agriculture supplemented by business and services. However, there is a severe water shortage during the dry season. There is a relatively high degree of social conflict over issues such as land and marriage. Compared with Saturia, village women are less mobile and *purdah* is observed more strictly. The research team therefore found it difficult to get permission from husbands and religious

leaders for nonpoor women to participate in the focus groups. Jessore is the least conservative area of our study and is reasonably prosperous. Despite this, there is a high level of social and class tension, which produces a high level of fear and insecurity among the poor.

Despite these general variations in vulnerability context, the variations in vulnerability between different social categories within each site were greater. Therefore we break vulnerability down into three aspects, as elaborated in the following sections.

Social and Political Dimensions of Vulnerability

The nonpoor households in Saturia reported less vulnerability, because they have access to cash and extensive kin support networks to assist with cultivation. It was also reported that some poor and very poor adopters of vegetables distribute produce to family and neighbors as a way of building and maintaining social solidarity. One very poor woman in Saturia remarked: "we distributed vegetables among our family and other relatives, and we also gave them to those among our neighbors who have not grown vegetables." This was a key insight from the qualitative research that was not apparent from the quantitative data.[5]

Vulnerability in this area is also a function of membership in the wider community. In this area of Saturia, there is a substantial Hindu minority, some of whom reported discrimination. Many Hindus are found among the poor and very poor categories.

There is a gender dimension to vulnerability. For women, movement between private and public space is problematic. Poor women make an important distinction between outside work (*bairer kaj*) as paid, and inside work (*ghorer kaj*) as household work, which is unpaid. They combine a range of activities, such as paddy husking,

[5] It was interesting to note gendered differences within focus group discussions on this issue, where men and women can be seen to place different values on goods and transactions. A male poor group member did not see value in distributing vegetables to relatives: "How can we give things of low status as gifts? Vegetables should not be given to the father-in-law's house."

producing and small-scale trading of *mourri*, and sewing the traditional *katha* (a Jessore local speciality)—all hard work for small returns.

There is a perception among the poor that their plight is ignored by those who are better-off. One of the male poor groups said many people have a good economic situation but that few of the rich ever help the poor. "In this area the overall situation is not so bad. But he who has, has; he who has not, has not. Because of self-interest, the rich do not bother to uplift the poor."

The poor are disproportionately affected by law and order problems. There is the perception of an increasing crime problem. We were told that while people may know who the criminals are, there is a culture of fear, and it is dangerous to try to do anything about law and order problems. The poor women explained that nobody speaks out unless they want more trouble.

Adoption and Vulnerability

Adoption of agricultural technologies can reduce vulnerability through increased income, strengthening of social relationships, and strengthening of self-confidence and problem-solving capabilities at the individual level. The nonmaterial side to vulnerability is also useful in highlighting the ways in which very poor and nonpoor can successfully use the technologies to build social relationships (e.g., distributing vegetables to friends, neighbors, patrons) to build both horizontal and vertical ties that can reduce their vulnerability.

The study found that economic and social empowerment generally follows adoption of these technologies, but that vulnerability can be reduced or increased independently of increases in income. For some people who do adopt, new forms of vulnerability can arise related to the technology. This is particularly true in relation to fish. In Mymensingh, for example, it was reported that fish polyculture carries some distinct vulnerability problems of its own. Fish can be stolen, poisoned, or suddenly stricken by disease. They are highly perishable and need to be sold quickly if they are

grown in seasonal ponds. In Jessore, group-operated fish production was found to be subject to the same problems, with added social dimensions of mistrust within groups, and "principle and agent"-type incentive problems between poor groups and nonpoor pond owner-lessors.

This problem of post-adoption vulnerability can disadvantage women adopters, who may find themselves working harder to produce vegetables or fish but have no direct access to the market or control of the cash profits.

In the case of vegetables, it was found that the technology was relatively easy to adopt and unlikely to increase vulnerability, because these were cultivated on homestead land where security was easy to ensure and access did not bring a time cost. Nor was there likely to be a displacement of other crops, since homestead land tends to be unutilized for cultivation. Failure of vegetables does not, therefore, imply the loss of other income-earning opportunities. Moreover, the ability to produce vegetables within the *bari* (homestead) was deemed attractive to women and their families, since this activity brought less vulnerability to harassment and loss of reputation than working outside.

Adoption can therefore both increase and reduce vulnerability—but the general picture is that vegetables were relatively easy to adopt (compared to fish) and were unlikely to increase vulnerability. In general, we found that it was a difficult task to collect a wide range of qualitative data on the vulnerability context. It was easier for people to talk about the impact of the 1998 floods (in the sense of vulnerability to natural hazards) but more difficult to discuss social vulnerability in the focus groups. Focus groups may not be the most effective means for the collection of this kind of information, due to its sensitivity.[6] Also, this perhaps reflected a tendency for people to recall only dramatic episodes and events of vulnerability rather than systemic or the everyday experience of vulnerability.

[6] While we were not able to test this hypothesis conclusively, evidence from other recent research (e.g., Kaplowitz and Hoehm 2001) suggests that individual interviews and focus groups tend to produce different, often complementary, types of information.

5. Assets, Adoption, and Organization

In each study site, technologies were officially disseminated through a local NGO or government extension program. A household resident had to be a member of this organization to gain access to the technology and related services offered. Therefore, we examine technology adoption and organization membership in conjunction.

Quantitative Findings Using the Census Data[7]

This section reports on data from a household census undertaken in each site prior to the household survey. Census—not household survey—data are used to examine household-level determinants of technology adoption and NGO membership, since they give a representative view of the adoption and NGO membership scenarios in each site. Although the information on assets in the census is not as comprehensive as in the survey, important physical and human capital information is available. The two binary outcomes are modeled in the statistical analysis as jointly determined. Because the technologies being studied differ by site, analysis is undertaken separately by site.

As shown in Appendix Table 8, membership in an organization (including, but not limited to, the key institution disseminating the technology) is highest in Saturia. This site is closest to Dhaka and has a large number of NGOs providing a variety of services. Mymensingh is the site with the highest proportion of technology adopters—almost one-third of households.

Appendix Table 9 displays mean within-site differences between organization members and nonmembers. The only notable differences observed are that in all three sites, nonmembers have more cultivable land area; in the fishpond sites, nonmembers own more homestead land. This is consistent with the World Bank Bangladesh PPA finding that large landowners are not often NGO members, presumably because they do not need the services provided by NGOs, such as credit and training.

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[7] This section draws on analysis performed jointly with Agnes Quisumbing.

Appendix Tables 10–12 present summary statistics on household-level livelihood assets by adopter (*A*), likely-adopter (*B*), and nonadopter and nonlikely-adopter (*C*) status. Most of these characteristics are rather long-term in nature and therefore not likely to have been affected by introduction of these technologies. Across all sites, adopter and likely-adopter households differ only along a few dimensions. Means tests indicate that in the vegetable site, Saturia, lead men in *A* households are slightly more likely than those in *B* households to have at least some primary education. In the private fishpond site of Mymensingh, lead *B* males are somewhat older and slightly more likely to have at least some primary education, although higher-level education attainment does not differ; *B* households also have an average 25 percent more land than *A* households. In the group fishpond site of Jessore, *A* households are more likely to be male-headed and have older lead males. Lead females in *A* households are somewhat less likely to have at least some primary education, but there is no difference in higher-level female educational attainment. In sum, while *A* and *B* households vary along a few important asset measures, the advantages are not unidirectional or extraordinarily large. These results indicate that comparing mean differences in key livelihood outcomes for adopter versus likely-adopter households may not be a perfect method for assessing technology impacts. However, it is likely to be instructive, especially if the technology is not "purposefully located" in villages with certain characteristics. We return to this issue below.

Multivariate regression results of the determinants of NGO membership (yes or no) and technology-adopting intentions (adopt/intend to adopt or not) are presented in Appendix Tables 13–15. A bivariate probit estimator is used to allow these binary (yes/no) outcomes to be interdependent decisions, since NGO membership could be driven by demand for the agricultural technology and vice versa. Results reveal that common characteristics increase participation in NGO-type organizations across sites. Households with more members are more likely to be NGO members. This could indicate that scale factors may be important determinants of benefiting from such programs. If a critical mass of individuals is available to meet basic domestic and

agricultural tasks, other members may be free to participate in development program activities. Higher lead female education also increases the chances of NGO membership, but educational attainment of the lead male and a greater number of males over age 15 in residence reduce the probability of NGO participation. These results indicate targeting of NGO activities to females more than males. More preschool children in residence reduces the likelihood of NGO membership; this is important programmatically, given that many NGO programs in rural Bangladesh target females. Young children to care for may decrease mothers' likelihood of participating in such programs. Finally, more non-homestead land area reduces the chances of being a member of an NGO; it is likely that these wealthier households have less demand for NGO services and that NGOs target and serve medium and small landowners.

Quantitative Findings Using the Survey Data

Purposive placement of interventions is a concern when assessing program impact. If technologies are disseminated to areas that are either more prepared to benefit from their availability or are more in need of them, comparing with and without areas will produce biased and potentially misleading conclusions about program impact. There are two predominant approaches to dealing with this potential problem: (1) a fixed-effects (difference-in-difference) estimator, or (2) an instrumental variables approach. Both depend on what data are available. The first approach (e.g., Pitt, Rosenzweig, and Gibbons 1995) tests whether changes in outcomes are greater in areas where there are greater changes in program coverage net of changes in individual-, household-, and community-level factors. As an illustration, consider

$$Y_{ij} = B_1 X_{ij} + B_2 H_{ij} + B_3 Z + B_4 P_{ij} + B_5 \omega_{ij} + э_{ij} , \qquad (1)$$

where Y is the outcome of interest; X is a vector of individual characteristics; H, a vector of household characteristics; Z, a vector of community characteristics; P, the measure of program exposure; T, a vector of unobserved individual-, household-, and community-

level characteristics, and ɜ, a random disturbance term that is assumed to be uncorrelated with the independent variables in the model. For the purposes of estimating program impact, the parameter of primary interest is *P*, indicating the effect of exposure to the technology. This approach requires that data on each element in the regression be available at two or more points in time, as shown in equation (2) (note: the subscripts "1" and "2" indicate time periods 1 and 2, respectively):

$$Y_{ij2} - Y_{ij1} = B_1 (X_{ij2} - X_{ij1}) + B_2 (H_{ij2} - H_{ij1}) + B_3 (Z_{j2} - Z_{j1}) + B_4 (P_{ij2} - P_{ij1}) + (ɜ_{ij2} - ɜ_{ij1}). \quad (2)$$

Because they do not vary over time, fixed unobserved factors in vector *T* are "differenced" out, and as a result, estimation of equation (2) does not result in biased coefficient estimates of B_4, reflecting the impact of exposure to the technology. This approach cannot be used here since we do not have information on differential program exposure at two points in time. *B* villages were without the technology for the entire survey period, and changes in exposure in *A* villages over the survey period were not measured (most likely because the surveys covered only a single agricultural year).

The second approach uses "instrumental variables" methods. The model has two equations: a technology exposure equation (equation 3) and an outcome equation (equation 4).

$$P_{ij} = B_1 X_{ij} + B_2 H_{ij} + B_3 Z_j + ɜ_{1ij} , \quad (3)$$

$$Y_{ij} = B_4 X_{ij} + B_5 H_{ij} + B_6 Z_j + B_7 P_{ij} + ɜ_{2ij} , \quad (4)$$

where P_{ij} represents the exposure to the technology of person *i* from community *j* over the period of observation, $ɜ_{1ij}$ and $ɜ_{2ij}$ are error terms, and all other terms are as defined above. Bias in the model is an issue to the extent that $ɜ_{1ij}$ and $ɜ_{2ij}$ are correlated. To remove this correlation, a two-step estimation procedure can be used in which equation (3) is estimated first and the coefficient estimates used to predict the level of exposure to the technology. The predicted exposure is then included in equation (4) as an

independent variable. The notion is that the program exposure variable in the outcomes equation is purged of the distorting effects of common unobserved determinants of program exposure and the outcome being examined. This yields consistent estimates of the impact of program exposure in equation (4). To econometrically identify the model, at least one instrumental variable should appear in equation (3) that is not included in equation (4). Instrumental variables are hypothesized to influence an outcome of interest only indirectly through their effects on program exposure. Since program exposure in this study is at the village level, village characteristics are used to investigate the issue of purposive ("endogenous") program placement.

At the time of the third and fourth rounds of household surveys in 1997, interviews with key informants in the community were undertaken to assess the availability of infrastructure and services in each village, with different questions asked at each round. Appendix Table 6 presents a comparison of long-term characteristics of technology-recipient and technology-pending villages. Most factors shown are unlikely to vary in the short run, due to technology successes or failures. Thus they are not attributable to the technology's presence or absence. An indicator of particular interest from the point of view of the NGO "distributing" the technology is the travel time from the NGO office—usually in the *thana* seat—to each village. In these data, two potential measures are available: (1) travel time from the village to the main *thana* health center, and (2) distance from the village to the office of the disseminating organization (estimated ex post by the firm that conducted the surveys). If more accessible (often implying better-resourced) villages were chosen for early introduction, this could bias results *A* versus *B* household means comparisons. Appendix Table 6 shows that while *A* villages are closer than *B* villages to each respective NGO office, the differences are not significant. Travel time from *A* villages to *thana* health centers are also shorter than travel time from *B* villages, but the difference overall and in Mymensingh is significant. (*Thana* health centers are in the *thana* main city, which is where each agriculture disseminating institution's office is also located.) In general, *A* villages appear to have better access to health and education infrastructure than *B* villages.

Further evidence of the determinants of technology-recipient versus technology-pending villages is shown in the probit regression results in Appendix Table 16. The village characteristics described above are used as instrumental variables to determine whether a village is a technology recipient or not. None of these variables appears in the outcome regressions and so they are valid instrument candidates (site dummies are used to capture location effects in the outcome regressions). Careful examination of correlation among village characteristics resulted in several regressors being dropped in the present version of the technology placement village regression. While it would have been preferable to run site-specific regressions, the small number of villages in each site prevented this. Although no single village characteristic is strongly significant, proximity to the *thana* health center and the village not having electricity are both significant at the 10 percent level. Parameter tests reveal the joint significance of the group of variables.

We also compare mean asset positions of adopter versus likely-adopter households using data from the first round of household surveys. As presented in Appendix Table 12, adopter and likely-adopter households have similar asset holdings. In the instances where differences exist, the patterns of advantage are not unidirectional.[8]

While findings from the community survey provide some weak evidence that the technologies may have been placed non-randomly in villages, comparisons of adopting households in technology-recipient villages and likely-adopting households in technology-pending villages reveal that households overall have similar livelihood asset positions. To address the possibility of biased impact findings due to potentially nonrandom program placement, impact regressions with *A* village status predicted from the above probit regression are presented.

[8] The percentage of women below the height of 149 cm is an indicator of higher risk of pregnancy complication and maternal mortality (WHO 1995). Only a continuous height measure was used for males, since there is not an analogous pregnancy risk height cutoff indicator.

Qualitative Findings Based on the Focus Groups

The focus groups suggest that membership in NGOs and other organizations is weighted toward the poor, but that asset ownership/power also allows some nonpoor households (but not the wealthiest) to become NGO members. At the same time, there are some very poor households who find themselves excluded from NGO membership because they are asset-poor (e.g., some report that they may be unable to keep up with loan repayments or do not have necessary collateral assets of documentation).

It was also reported that lack of social connections contributes to isolation for the very poor, which makes it difficult to become part of an organization. Lack of education can also make poor people unconfident about joining an organization. In the case of government extension, status issues make it harder for the very poor and the poor, and females, in particular, from those groups, to gain access to public services. NGOs in general are better at overcoming these barriers.

A certain level of material and nonmaterial assets is a precondition for adoption. It was striking that it was the poor who tended to have the widest range of livelihood strategies, while the very poor and the nonpoor had fewer.[9] Lack of access to financial resources is, as might be expected, a key element of vulnerability. The male very poor in Jessore said that they could not easily reduce their vulnerability without access to cash. Although money cannot solve all problems, it can solve many of them, they said. Credit is therefore very useful. They say that if they cannot maintain their basic household expenditure, how can they be expected to expand into fish production? First, money is needed, then advice and information.

For many of the poor, financial vulnerability makes it unlikely that they will be able to adopt new technology. This was apparent in focus group discussions regarding microcredit services from NGOs. For very poor people, the pressure of taking a loan that has to be strictly repaid in weekly installments and that demand regular group meetings can act as a disincentive to adopt technology.

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[9] This pattern is consistent with that noted by Reardon, Berdegué, and Escobar (2001) for Latin America.

The finding that has emerged from other recent studies is that these technologies—and NGOs/credit services, in general, (e.g., Hulme and Mosley 1996)—cater most effectively to the poor rather than to the very poor. This is supported by the focus group data.

However, lack of adoption is also attributed to other factors, including lack of access to an NGO "samity" or group (either due to lack of availability, or a self-imposed reluctance to join); for women, a reluctance to go outside the household; lack of access to land or a pond. The problem of a lack of control over irrigation water was cited by a male poor group in Saturia, since the government Power Development Board, which controlled the local tubewell, cut the water supply after the rice-growing season ended. This, then, made it difficult to find water for vegetables.

A lack of both material and nonmaterial assets were shown to be significant and interrelated in constraining household choices. For example, in a straightforward sense, one very poor group member in Saturia said: "We have no land, so we can't do anything. If we had some land, then we would cultivate vegetables." Another female very poor group member from Jessore said: "Since we were very poor at the time it started, we could not get involved with the samity."

6. Findings on Transforming Structures and Targeting

Introduction

The main finding is that in all three communities, the poor generally held a more positive view of nongovernmental actors than of governmental ones; the latter were seen as remote and sympathetic only to the interests of the rich. However, people saw a marked difference among various NGOs, and observed that NGOs vary considerably in competence, integrity, and operating style. NGOs disseminating technology for adoption by individual households met with more success than those promoting group-based or collective adoption. In relation to targeting, it was found that NGOs do reach the poor

relatively effectively. However, many of the very poor tend to be excluded, due to lack of resources, and there are many cases of nonpoor members participating in NGO groups.

The Situation in Saturia—Vegetables

In Saturia, recent infrastructure improvements have made vegetable sales more profitable, with new roads reported by several informants. However, there was almost no contact reported in the groups between villagers and any government offices or programs in support of agricultural development, only with NGOs. The AVRDC seeds were originally disseminated by GKT, but this NGO is now seen primarily as a source of credit and only secondarily as a source of vegetable technology, which is also available more widely. Many villagers are now producing and storing their own seeds instead of buying them from GKT, although there are reports that seed quality varies. The consensus seemed to be that while GKT has initially done a very good job of promoting the technology in the early 1990s, it is now less effective. Many people have withdrawn from the GKT program. Some people reported being coerced into taking seeds when they only wanted credit. Others complained they had been forced to contribute to pension savings schemes. There were many complaints about the lack of timeliness in delivery of seeds and credit. Some informants complained of rough treatment or lack of attention from NGO staff. In later interviews with NGO staff, we were told that many of these problems were localized and had been addressed through staff changes. According to some informants, other NGOs, such as BRAC, are now providing better credit and seed services in the area. These perspectives illustrate the dynamic quality of NGO service provision over time and the range of different perspectives on the effectiveness and responsiveness to local needs of such provision.

The Situation in Mymensingh—Individual Fish Cultivation

In Mymensingh, adopters do not refer to the government MAEP project at all, but instead perceive Danida as the organization that is introducing the technology. Most

people do not have much respect for the government's extension services. Even nonpoor males say that the *thana* fisheries officer does not provide any services nor visit the village:

- "There is no government hatchery. There is a government fisheries organization in the district, but it is not active."
- "The government people are there, but they just exist on the record, not for us."
- "The government officers are just there for their own interests. They sit in their offices, but they don't come to us."

Information about fish culture is also gained informally from people involved in the fish business, such as hatchery owners, fishermen, and fish traders outside the Danida project. In this way, some fisheries technology information is being extended informally though private-sector sources.

The Situation in Jessore—Group-Based Fish Cultivation

In Jessore, the services received from the NGO were adequate in the first instance, but problems had arisen among the group members. The poor women's focus groups reported that these organizational problems made the technology unsustainable, not the technology itself. The fact that the NGO Banchte Shekha leased the pond and then provided training and advice was seen as a good strategy. However, the problem reported by the focus groups was that the staff of Banchte Shekha did not supervise the groups after this point and the groups tended to fall apart. The result was that the group leaders were able to misappropriate the group funds and exploit members—they were not held accountable to the NGO. The group members then stopped participating. Nonpoor males reported that credit, training, and irrigation facilities were all necessary services for modern fisheries. The nonpoor women's explanation for group failure was that members did not take the group seriously, only five of 21 members were given training by Banchte Shekha, and the group was too big and could not be easily united or cooperative. The

different explanations are illustrative of the fact that different social categories lead to very different perspectives on technological change; these perceptions influence adoption behavior.

Perceptions of Service Delivery and Targeting by Dissemination Agencies

In general, people are more positive about the role of NGOs than government services. In the case of government extension, status issues make it harder for the very poor and poor, and females, in particular, from those groups, to gain access to public services. NGOs, in general, are better at overcoming these barriers and reaching the poor, but many nonpoor households also become members, while many very poor households are excluded because of social exclusion, lack of confidence to participate in groups by those with low education, or lack of assets, which makes it difficult to keep up with loan repayments.

Can Agencies "Empower" the Poor?

Adoption of the technology, where successful, brings empowerment for women in the sense that earning money can increase their decisionmaking power within the household, and—in some areas—create opportunities to move into public space, such as the market, to sell produce. The gains in confidence reported by women NGO group members arises from the solidarity of the group and the added status of being part of an outside organization. There is also a strong demand from the community for more training and other services from NGOs. However, some women report that joining an NGO may have political/social/factional implications and that the NGOs (like the government) are not neutral. Very poor female groups reported: "They [NGOS] don't treat us all equally," and "They only give seeds and loans to people with whom they have a good relationship." This unequal treatment may be disempowering. In the group-operated fishponds, lack of adequate NGO supervision is given as a reason for failure and this contributed to disempowerment.

7. Findings on How Technologies "Fit" into Livelihood Strategies

Introduction

The main finding is that since the poor are engaged in multiple income-earning strategies, technology adoption needs to take account and juggle a range of activities within an overall livelihoods portfolio. Questions of technology adoption therefore need to be understood in relation to their overall "fit" within these multiple strategies—especially for the very poor, who tend to have the most diversified livelihoods. A second key finding is that adoption is time consuming, but adopters perceive that the return from adoption outweighs the burden of the extra work.

The Situation in Saturia

In Saturia, where vegetables have been introduced, the fit with women's livelihood strategies is generally a good one among all wealth categories. For small-scale homestead vegetable cultivation, the vegetable technology requires very little land, no real need to move beyond the homestead, low levels of cash investment, flexibly timed labor inputs, and a high level of nutritional benefits. Vegetable cultivation can be coordinated with all of the many other household tasks relatively easily. However, adopters who wish to undertake the cultivation of vegetables on farmland beyond the homestead, and the sale of vegetables by women in the market, are definitely constrained by the public/private space dichotomy. However, there are cases where this is being challenged (see below).

Seasonal commitments vary strongly between the groups. Poorer women have no savings and therefore need to work steadily to secure income throughout the year. They tend to be less busy in July–August, when there is less work available (the rainy season). Nonpoor women have a shorter busy time, October–March, when they are concerned with pre- and postharvest rice work. The nonpoor tend to cultivate a smaller range of vegetables than the poor, because they do not bother with vegetables, which they can easily buy from the market (such as chilies). Instead, they give more importance to their

wider household-related work during this period, such as paddy husking, seed preservation, and *kata* sewing for winter.

The Situation in Mymensingh

In Mymensingh, agriculture used to be the main occupation in the village, but now it has been joined by the new fish polyculture technology as the second most important source of income. Fish cultivation has become a business, providing a source of cash when needed; therefore, it is a source of security for some households. Now fish production has become a commercial business—even among the relatively few poor men who have adopted it—and it is no longer just for consumption.

However, those who cultivate shared ponds (as opposed to owned ponds) have less access to fish for consumption on a regular basis. Apportionment has to be negotiated with other members of the group, who may decide that in different months, certain people can consume fish. This is an important difference between single-owned and shared-access cultivation identified by very poor women.

There are strong status reasons why husbands do not want their wives involved in these aspects of fish production. Women would be willing to get more involved if there were not such social pressure that makes them vulnerable. One poor woman said, "Fish cultivation is related to the market, so this is dominated by men, and women cannot talk with the men." Another said if she did not have a husband, she would go to the market, but other villagers would criticize her.

The Situation in Jessore

In Jessore, the collective fish technology has been less successful, mainly due to the failure of organizational arrangements and lack of trust—at times justified—in relations between NGO staff and beneficiaries (see Section 6). The public/private space dichotomy is another constraint on women's "room to maneuver," and hence distance to ponds was an important constraint on adoption. One non-adopter said that she had

wanted to adopt the technology, but the pond was not close to the homestead. One reason for group failure was because there were always group members who were unable to go to the pond. Younger women were compelled to send older household members—such as the mother—to feed the fish and visit the pond.

Although they are aware of the technology, there are still nonpoor households that continue with traditional "extensive" fish cultivation for consumption. There is a belief that if modern varieties and techniques are used, the fish do not taste as good. Since they have other sources of income, some nonpoor males say they do not therefore have adequate incentives to move into commercial fish production.

8. Findings on Outcomes

Impacts on Empowerment

Quantitative Findings

In the fourth-round household survey, one year after households had first been interviewed and some familiarity had been established between respondents and the survey teams, a module on intrahousehold decisionmaking was included in the survey instrument. A number of dimensions of male-female bargaining and interactions were measured. Patterns of male versus female asset ownership, contribution to household income, household expenditure patterns, and child health status—and their determinants—have been examined in other research using these data (Quisumbing and de la Brière 2000; Hallman 2000; Quisumbing and Maluccio 2000). Therefore, this section focuses on describing some empowerment measures that have not been discussed elsewhere. These include physical mobility, control over resources, domestic violence, and political knowledge and activity—factors identified as important indicators of empowerment during qualitative research in the study communities (Naved 2000).

As shown in Appendix Table 18, there are a number of significant differences between women in adopting and likely-adopting households. For most outcomes, NGO-

member technology-adopting women (in *A* households) have "better" outcomes than NGO-member likely-adopting women (in *B* households). In each study site, women from *A* households were more likely to have visited friends/relatives outside the village, attended an NGO training or program, and been able to name political leaders at local, state, and national levels; "*A*" women were less likely to report having been beaten or verbally abused by a husband or a family member.

A versus *B* differences are found by study site, with the most noticeable in Saturia, the vegetable technology site. Here, women in *A* households reported more mobility and political awareness than women in *B* households. This site may have seen the largest number of *A* versus *B* differences because it was the only site where the technology was both targeted to women, and the extension effort was successfully delivered operationally.

In the private fishpond site of Mymensingh, although the technology was officially targeted to women, in practice, it was often men who operated the ponds. This is the most culturally conservative community of the three study sites. Even though fishponds are privately owned and usually located on land owned by the household, the ponds are largely outside the household compound, making it more difficult in practice for women here to operate them. In this site, women in *A* households report a greater ability to save for their own expenses and security. It appears to also be the case, however, that such savings may increase vulnerability to some degree: women in *A* households report having their money and assets taken against their will more often then women in *B* households. Other indicators of "empowerment" are no better for *A* than for *B* women in this site.

In Jessore, the group fishpond site, there are a few differences between women in *A* and *B* households, and those differences favor *A* women. They were more likely to have attended NGO training or programs (true across all three sites), less likely to have been beaten by a husband or family member (although the levels for all women in the study are very high), and more likely to have chosen whom she voted for in her last voting act.

The multivariate results shown in Appendix Table 19, which include women from *A* and *B* households and with *A* village status predicted, show that women in *A* households were generally more likely to work for pay and be able to save money for their own expenses and security than women in *B* households. The site-specific results show a mix of effects. In Saturia, women in adopting households reported visiting friends and going to the market more, but attending NGO training sessions less. The latter effect might be because after the introduction of the vegetable technology, the availability of seeds and support training was poor (reported during our numerous visits to this site). In Jessore, on the other hand, *A* women reported attending NGO training sessions and programs more, reflecting the group-based nature of the technology delivery and the fact that ponds were located away from the *bari*; these women also had higher rates of working for pay. In Mymensingh, although *A* women could more easily name the Prime Minister, they were more influenced by others in their voting decisions. They were less likely than *B* women to report having assets forcibly taken by husband or relatives.

Focus Group Findings

Extension and empowerment. In general, people are more positive about the role of NGOs than government services, and women NGO group members report gains in confidence from NGO membership. There is a strong demand for more training and other services from NGOs.

Some women report that joining an NGO may have political/social/factional implications and that NGOs are not neutral in their treatment of all groups. In the group-operated fishponds, lack of adequate NGO supervision is given as a reason for failure and this contributed to disempowerment.

Technologies and empowerment. For women who have gained direct access to cash income (in general, through vegetables, rather than fish), some women from the

poor report empowerment through an improved understanding of "money matters" and also "if you have money, then you have status."

Higher female status is given as an outcome of adoption by women's groups. "Now women give money to their husbands from their own earnings. Once husbands would have been angry about this, but they don't say anything now." Several of the groups reported changing norms subsequent to adoption—e.g., if women go outside the home in pairs or groups, "no one complains nowadays."

Education level is also improving after adoption: "If I didn't grow fish, I could not educate my children" (FVP). While the additional income may be negligible in monetary terms, it is likely that this woman is reporting the empowerment effects of managing this new income, which is contributing to a stronger intrahousehold bargaining power.

Overall Impacts of Technologies on Well-Being

Quantitative Findings

As presented in Appendix Table 20, expenditures do not differ significantly between adopter and likely-adopter households: total monthly per capita expenditure and the percentage of the household budget spent on food are no different. Some components of expenditure do differ, however. Expenditure on inputs to agriculture varies by the availability of the technology. Outlays for hired labor on crops are larger for likely-adopter households, while hired labor and nonlabor inputs to ponds are greater for adopting households. This most likely represents a shift from inputs to rice to those related to the new technologies.

There are a few differences for individual nutrient intakes, and nutrition and health outcomes, and they are mainly in the direction that individuals in adopting households are slightly better-off than those in likely-adopter households.

Differences in dietary quality (percentage of calories derived from nonstaple plant foods) are seen for certain types of household members. School-age children,

adolescents, and older adults in adopting households have a larger share of calories derived from green leafy vegetables than the same types of individuals in likely-adopter households.

Adolescent girls (nutritionally and socially a very vulnerable group) in adopting households consume more total calories, while adult men consume fewer calories and older men have a lower percentage of their diet from animal sources than those in likely-adopter households.

School-aged and adolescents in adopting households have better nutritional outcomes: both groups in adopting households are slightly taller. Preschoolers and older adults in adopting households have less acute and chronic illness than their counterparts in likely-adopter households.

Household expenditure and income regressions (Appendix Table 21), which include *A* and *B* households with *A* village status predicted, show no significant effects of access to the technology on total household expenditure per capita or overall. Income effects are observed, however. In the pooled sample, *A* relative to *B* households have greater nonfarm and farm incomes (higher crop and pond profits). By site, no household income effects are found in Saturia (given the small scale of the technology). In Mymensingh, however, *A* households have greater crop and pond profits and farm incomes. In Jessore, access to the technology increases off-farm and total household income; this may, in part, reflect the increased likelihood of *A* women there to work for pay.

Nutritional status regressions for children and adults show no effects of the technologies in the pooled sample, but access to the technology has strong positive effects on preschooler height-for-age Z-scores in Saturia, especially for boys. Among adults, the technology is shown to have positive impacts on women's body mass index in Jessore.

Focus Group Findings

The most positive stories are from the vegetable site of Saturia, and from the individual-pond site of Mymensingh (e.g., "Before we could only eat fish—now we can sell it as well and solve some of our problems"). The group pond work in Jessore seems to be the least successful—many people here are left embittered with the failure of the collective action, and the NGO concerned.

Both of these findings have implications for future scaling up. In the case of the vegetable case study, there is clearly scope for this technology to have wider impact in terms of poverty reduction. Saturia is, of course, known to be one of the centers of vegetable production in view of its high land, rich soil, and proximity to Dhaka markets. However, the nonlumpy character of this technology and the potential nutrition, gender empowerment, and social network benefits to poorer groups from even very small-scale adoption is apparent from the study. On the other hand, the dedication and commitment to the "cause" of vegetables by GKT has clearly played a key role, and care would have to be taken with the selection and training of other NGOs that might undertake this type of work.[10] One of the benefits of this technology is that it can remain small-scale and household-based, although it could also lose its gender benefits in contexts where growers can connect with markets and export potential.

9. Conclusions

Poverty, Impact, and Vulnerability

The study found the strongest poverty impact in the case of the vegetable technology, which is targeted toward women in households with relatively small amounts of land and is essentially a nonlumpy technology that requires a very low level of investment, but with disproportionately significant returns to the very poor and signs of

[10] It was also clear from the focus group discussions that GKT itself has been through a difficult period, during which relations had broken down in some communities, due to inappropriate behavior by some field staff. Some staff were subsequently dismissed.

positive impact on female empowerment and child nutritional status. The noneconomic benefits of this technology (at least in the direct sense), in terms of network building and reciprocity, were also apparent in the study. The private fishpond technology was less successful in terms of poverty impact, since only better-off households tend to own ponds; this technology, however, had positive effects on the pond and crop profits of these households. The operation of the group fishpond technology, though a potentially beneficial agricultural program for poor households, was significantly undermined by collective action problems. Relative to women who did not have access to this group-based program, however, female fishpond group members appeared to have more mobility, greater likelihood of working for pay, higher off-farm incomes, and better nutritional status.

It was also found that technology has the capacity to increase vulnerability in a number of ways, such as through the theft of fish or through intrahousehold inequalities that lead to coercion, i.e., women who begin to gain income are compelled to pass on resources to husband and/or in-laws. Institutional factors may also contribute to increased vulnerability, as in the case of the collective action problems that contributed to group fishpond failures. The qualitative element of the research showed a higher level of trust for NGO as opposed to government services, but it also highlighted the variable performance of NGOs. Political dimensions to NGO activity were also shown to be important, and are perceived by some sections of the community to affect the dissemination of technologies and extension support services for the technologies.

Research Methodology

Quantitative and qualitative data were found to complement each other well in the research across a range of issues. For example, the survey addressed female empowerment adopters in terms of measuring the frequency of women's visits outside the home, attendance at meetings, knowledge of local politics, etc., while the focus groups revealed interesting material on the nonmonetary exchange of vegetables between

households to build and maintain social networks in the attempt to reduce vulnerability. However, the time lag between the quantitative and the qualitative data collection was a weakness of the study, since it was sometimes found that earlier findings were out of date by the time of the focus group meetings. Nevertheless, the approach was found to be useful, and there were gains in the overall use of the SL framework as a way of sharpening understanding of the different entry points at which technology can affect household well-being and vulnerability.

A particular strength of combining the social and economic approaches here is that questions that cannot easily be answered by a quantitative survey (even such a thorough one as this) are being informed by a series of qualitative studies with households, groups, and institutions in the survey areas. These include issues such as perceptions of poverty, livelihoods strategies, the institutional setting, and technology dissemination pathways.

Wider Implications

What lessons might be drawn from this research in relation to wider questions of the relevance of technological research to poverty reduction issues?

First, understanding the reality of poor people helps agricultural research to reach and benefit this important clientele. Technologies that build on the assets that the poor have (e.g., homestead land) are more likely to be adopted by, and benefit, poor households and individuals. Conversely, technologies that require high threshold levels of certain assets, such as land or financial capital, are likely to exclude the poor, unless programs find other arrangements to work around the assets they lack (e.g., group-leased fishponds for those without ponds of their own). Similarly, technologies that reduce vulnerability will provide greater benefits for the poor than those that are riskier.

It is not only the technology that matters, but also how it is disseminated. Special efforts to reach poor households, and especially the women within those households, were key to achieving poverty impacts. Untargeted dissemination is more likely to

benefit men and better-off households. Reaching women with the technologies provided empowerment effects that led to welfare increases greater than the income effects alone might indicate. The disseminating institutions—whether government, NGO, or social networks—also play a pivotal role in building trust, both with the technology and within the community. Hence, the technical competence as well as general approach of the disseminators are important.

In the case of the fish polyculture technology, many of the problems raised on the focus groups had more to do with the failure of broader institutional arrangements than with the specific technology itself. This warns us against decontextualizing technologies from their institutional and political settings, and it draws attention to the need to focus research in a more integrated way on holistic approaches based on sound contextual information.[11]

[11] For example, Lewis (1998) argues from data collected in the early and mid-1990s that the constraints on the poor using fish technology in Bangladesh have tended to be presented in terms of a technical problem instead of more accurately as institutional and political.

Appendix Tables

Table 6—Characteristics of sample villages

	All sites			Saturia-vegetables			Mymensingh-individual fishponds			Jessore-group fishponds		
	A village (technology-recipient)	*B* village (technology-pending)	P-value On diff. significance at 10% level or better	A village (technology-recipient)	B village *B* village	P-value On diff. significance at 10% level or better	*A* village (technology-recipient)	*B* village (technology-pending)	P-value On diff. significance at 10% level or better	*A* village (technology-recipient)	*B* village (technology-pending)	P-value On diff. significance at 10% level or better
Number of observations	27 villages	20 villages		5 villages	5 villages		14 villages	7 villages		8 villages	8 villages	
Key technology NGO-related												
Distance to key NGO office	4.45	5.05	no	3.10	4.30	no	3.61	3.00	no	6.75	7.31	no
Human												
Minutes to *thana* health center (wet season) (= 0 if in village)	49.63	67.75	**yes**	44.00	50.00	no	36.43	66.43	**yes**	61.25	80.00	no
Minutes to *thana* health center (dry season) (= 0 if in village)	39.07	51.50	**yes**	34.00	42.00	no	36.43	47.86	no	46.88	60.63	no
Minutes to nearest pharmacy (wet season) (= 0 if in village)									no			no
Minutes to nearest pharmacy (dry season) (= 0 if in village)	20.26	20.95	no	12.40	19.00	no	18.93	22.43	no	27.50	20.88	no
ORS available in village (1 = yes 0 = no)	0.93	0.75	**yes**	1.00	1.00	no	0.93	0.71	no	0.88	0.63	no
Has a BRAC school (1 = yes, 0 = no)	0.74	0.55	no	0.80	1.00	no	0.71	0.29	**yes**	0.75	0.50	no
Has a primary school (1 = yes, 0 = no)	0.74	0.50	**yes**	0.40	0.60	no	0.86	0.43	**yes**	0.75	0.50	no
Has a secondary school (1 = yes, 0 = no)	0.33	0.05	**yes**	0.20	0.00	no	0.50	0.14	no	0.13	0.00	no
Has a *madrasa* school (1 = yes, 0 = no)	0.33	0.20	no	0.20	0.00	no	0.50	0.00	**yes**	0.13	0.50	no
Has adult education classes (1 = yes, 0 = no)	0.33	0.40	no	0.80	0.60	no	0.07	0.00	no	0.50	0.63	no
Physical												
Distance to nearest paved road (kilometers)	1.44	1.26	no	1.65	0.60	no	1.53	2.11	no	1.15	0.94	no
Any household in village has electricity	0.63	0.85	**yes**	0.40	1.00	**yes**	0.64	0.71	no	0.75	0.88	no
Village has a market (1 = yes, 0 = no)	0.44	0.20	**yes**	0.40	0.20	no	0.57	0.00	**yes**	0.25	0.38	no
Minutes to nearest phone (= 0 if in village)	34.63	35.90	no	23.00	28.00	no	28.21	26.86	no	53.13	48.75	no

(continued)

	All sites			Saturia-vegetables			Mymensingh-individual fishponds			Jessore-group fishponds		
	***A* village**	***B* village**	**P-value**	**A village**	**B village**	**P-value**	***A* village**	***B* village**	**P-value**	***A* village**	***B* village**	**P-value**
	(technology-recipient)	**(technology-pending)**	**On diff. significance at 10% level or better**	**(technology-recipient)**	***B* village**	**On diff. significance at 10% level or better**	**(technology-recipient)**	**(technology-pending)**	**On diff. significance at 10% level or better**	**(technology-recipient)**	**(technology-pending)**	**On diff. significance at 10% level or better**
Minutes to nearest post office (= 0 if in village)	12.33	20.45	**yes**	7.80	14.00	no	12.79	15.57	no	14.38	28.75	**yes**
Minutes to nearest bus stop (= 0 if in village)	19.89	21.95	no	13.40	17.00	no	13.57	18.86	no	35.00	27.75	no
Minutes to nearest bus stop (= 0 if in village)												
Political												
Village has a Union *Parisad* representative (current or in past 5 years) (1 = yes, 0 = no)	0.74	0.90	no	0.60	0.80		0.93	0.86		0.50	1.00	**yes**
Social												
Number of mosques	3.04	1.72	**yes**	0.80	1.90	**yes**	4.57	1.43	**yes**	1.75	1.88	no
Village has a youth organization (1 = yes, 0 = no)	0.81	0.70	no	1.00	0.80	no	0.93	0.57	**yes**	0.50	0.75	no
Number of local NGOs with members in this village	3.48	2.90	no	5.00	4.80	no	3.21	1.57	**yes**	3.00	2.88	no
							3.21					
Natural												
Log value per decimal irrigated upland (1996 taka)	7.53	7.71	no	7.78	7.94	no	7.20	7.36	no	7.95	7.89	no
Log value per decimal irrigated lowland (1996 taka)	7.60	7.59	no	7.79	7.98	no	7.39	7.30	no	7.84	7.60	no
Tubewell as primary source for drinking water (1 = yes, 0 = no)	0.96	1.00	no	1.00	1.00	no	1.00	1.00	no	0.88	1.00	no
Number of tubewells in the village	45.19	48.85	no	54.40	59.80	no	42.71	22.86	no	43.75	64.75	no
Other												
Village perceived to be richer than neighboring villages (1 = yes, 0 = no)	0.41	0.30	no	0.40	0.60	no	0.43	0.14	no	0.38	0.25	no

Table 7—Rural well-being categories

World Bank PPA	Our study	Percent of study households overall	Percent of study households by site	Characteristics
Rich	Nonpoor	6	Vegetable: 4 Private pond: 11 Group pond: 2	Large landowners (approximately 5 or more acres); own cattle and draught power and agricultural equipment; able to hire laborers; generate surplus income for savings; no food deficits; good quality house structure; have tubewell and latrine; can afford to send children to school and use health care; women seldom work outside home; dominate local community power structures
Middle		45	Vegetable: 51 Private pond: 53 Group pond: 30	Medium landowners (approximately 1.0–4.5 acres) with some draught power and agricultural equipment; may take on sharecroppers; may have nonagricultural income sources; expenditures equal income; no food deficits; no housing problem; can afford to send children to school and use health care; take investment but not consumption credit; women do not generally work outside home; have two sets of clothes per year; some take credit from NGOs
Social poor	Poor	27	Vegetable: 27 Private pond: 20 Group pond: 35	Food deficits experienced but ability to somehow manage two regular meals per day during the slack season; small landholdings (0.3–0.6 acres) profits from which can meet 1–2 months' needs; adopt multiple livelihood strategies; occasionally work as wage laborers or in factories; women may work outside the home; own some homestead land but not high quality house; have no or poor water and sanitation facilities; very little to spend on clothing; trusted in community due to interaction as laborers with middle and rich; can borrow for consumption and repay; many are NGO members; express opinions in community but do not take leadership positions
Helpless poor	Very poor	17	Vegetable: 16 Private pond: 13 Group pond: 22	Landless; often live on others' land in dilapidated structures; wage labor in combination with sharecropping and fishing; accept low wages during lean periods; suffer from food deficits, especially children; women work as wage laborers; illness of a household member, particularly a wage earner can have devastating effects; do not have any assets to fall back on during crises; many are NGO members; have very poor clothing; cannot afford dowry for their daughters; cannot afford to entertain guests
Bottom poor		5	Vegetable: 3 Private pond: 3 Group pond: 10	Landless; households often headed by women or aged men and have not able income earner; going hungry is constant and not a seasonal occurrence; always working to eat; often forage for food and collect fuel to save on expenditures; begging is a source of livelihood; receive clothes donated at *Eid* festivals; high prevalence of illness; cannot afford health care; cannot take consumption loans because of inability to pay; most not able to join NGOs; have low social interaction with other groups; they attend feasts uninvited

Table 8—Summary statistics for census households

	Saturia			Mymensingh			Jessore		
Variable labels	**Observations**	**Mean**	**Standard Deviation**	**Observations**	**Mean**	**Standard Deviation**	**Observations**	**Mean**	**Standard Deviation**
1 = household member of any NGO; 0 = otherwise	1,989	0.53	0.50	1,979	0.28	0.45	3,254	0.39	0.49
1 = CGIAR technology adopter; 0 = otherwise	1,989	0.18	0.38	1,979	0.29	0.45	3,254	0.08	0.27
1 = "likely-adopter"; 0 = otherwise	1,989	0.10	0.30	1,979	0.14	0.35	3,254	0.05	0.23
1 = adopter or likely-adopter; 0 = otherwise	1,989	0.27	0.45	1,979	0.43	0.50	3,254	0.13	0.34
1 = male household head; 0 = otherwise	1,989	0.93	0.25	1,979	0.95	0.21	3,254	0.96	0.19
Lead male's age (years)	1,989	40.12	16.50	1,979	40.40	15.70	3,254	39.72	15.11
Lead female's age (years)	1,989	33.16	13.30	1,979	32.11	14.28	3,254	31.72	13.03
1 = household head is Muslim; 0 = otherwise	1,989	0.94	0.23	1,979	0.98	0.16	3,254	0.95	0.26
1 = lead male some primary education; 0 = otherwise	1,989	0.07	0.26	1,979	0.17	0.38	3,254	0.19	0.39
1 = lead male completed primary; 0 = otherwise	1,989	0.07	0.26	1,979	0.01	0.12	3,254	0.03	0.16
1 = lead male some secondary; 0 = otherwise	1,989	0.06	0.23	1,979	0.11	0.31	3,254	0.13	0.33
1 = lead male completed secondary; 0 = otherwise	1,989	0.03	0.16	1,979	0.05	0.22	3,254	0.05	0.21
1 = lead male some university; 0 = otherwise	1,989	0.08	0.27	1,979	0.05	0.23	3,254	0.03	0.17
Number of years resided in village	1,989	37.82	16.29	1,979	39.08	15.33	3,254	36.51	15.20
Log of household size	1,989	1.49	0.46	1,979	1.54	0.48	3,254	1.52	0.44
Number of male household members over age 15	1,989	1.62	1.13	1,979	1.58	1.03	3,254	1.57	1.04
Number of female household members over age 15	1,989	1.50	0.81	1,979	1.40	0.75	3,254	1.48	0.81
Number of children aged 5 or under	1,989	0.61	0.77	1,979	0.79	0.87	3,254	0.68	0.75
Nonhomestead land area in decimals	1,989	91.29	169.77	1,979	95.65	176.84	3,254	101.31	194.53
Area of homestead land in decimals	1,989	16.38	17.30	1,979	12.96	15.08	3,254	18.37	31.82
1 = lead female some primary education; 0 = otherwise	1,989	0.05	0.21	1,979	0.17	0.37	3,254	0.19	0.39
1 = lead female completed primary; 0 = otherwise	1,989	0.05	0.22	1,979	0.02	0.16	3,254	0.03	0.16
1 = lead female some secondary; 0 = otherwise	1,989	0.03	0.17	1,979	0.10	0.30	3,254	0.07	0.26
1 = lead female completed secondary; 0 = otherwise	1,989	0.01	0.09	1,979	0.02	0.13	3,254	0.01	0.10
1 = lead female some university; 0 = otherwise	1,989	0.01	0.10	1,979	0.01	0.08	3,254	0.00	0.06
1 = dummy for *B* (technology pending) village; 0 = otherwise	1,989	0.56	0.50	1,979	0.36	0.48	3,254	0.51	0.50

Table 9—Characteristics of NGO and non-NGO member census households

	Summary statistics—Saturia						Summary statistics—Mymensingh						Summary statistics—Jessore					
	NGO Members			Non-NGO members			NGO Members			Non-NGO members			NGO Members			Non-NGO members		
Variable	Obs.	Mean	Standard Deviation	Obs.	Mean	Standard Deviation	Obs.	Mean	Standard Deviation	Obs.	Mean	Standard Deviation	Obs.	Mean	Standard Deviation	Obs.	Mean	Standard Deviation
NGO member	1,059	1	0.00	930	0	0.00	557	1	0.00	1,422	0.00	0.00	1,283	1	0.00	1,971	0.00	0.00
A Household	1,059	0.33	0.47	930	0	0.00	557	0.30	0.46	1,422	0.28	0.45	1,283	0.19	0.40	1,971	0.00	0.00
B Household	1,059	0.18	0.39	930	0	0.00	557	0.10	0.30	1,422	0.16	0.37	1,283	0.14	0.34	1,971	0.00	0.00
A or *B* Household	1,059	0.51	0.50	930	0	0.00	557	0.40	0.49	1,422	0.44	0.50	1,283	0.33	0.47	1,971	0.00	0.00
Male-headed household	1,059	0.95	0.22	930	0.91	0.28	557	0.95	0.21	1,422	0.95	0.21	1,283	0.96	0.20	1,971	0.96	0.19
Age lead male	1,059	40.09	15.03	930	40.15	18.04	557	39.50	14.47	1,422	40.75	16.14	1,283	39.73	14.25	1,971	39.71	15.65
Age lead female	1,059	32.89	11.81	930	33.47	14.82	557	31.83	11.99	1,422	32.21	15.08	1,283	31.88	11.78	1,971	31.62	13.78
Muslim	1,059	0.94	0.23	930	0.95	0.23	557	0.99	0.10	1,422	0.98	0.18	1,283	0.92	0.31	1,971	0.97	0.22
Lead male some primary education	1,059	0.07	0.26	930	0.08	0.27	557	0.18	0.39	1,422	0.16	0.37	1,283	0.19	0.39	1,971	0.20	0.40
Lead male completed primary	1,059	0.07	0.26	930	0.07	0.25	557	0.02	0.13	1,422	0.01	0.11	1,283	0.03	0.16	1,971	0.03	0.16
Lead male some secondary	1,059	0.05	0.23	930	0.06	0.24	557	0.08	0.28	1,422	0.12	0.33	1,283	0.10	0.31	1,971	0.14	0.35
Lead male completed secondary	1,059	0.03	0.16	930	0.03	0.17	557	0.03	0.18	1,422	0.06	0.24	1,283	0.04	0.19	1,971	0.05	0.23
Lead male some university	1,059	0.07	0.25	930	0.09	0.29	557	0.02	0.14	1,422	0.07	0.25	1,283	0.02	0.13	1,971	0.04	0.20
Years resided in village	1,059	36.79	15.91	930	39.00	16.64	557	37.36	14.27	1,422	39.76	15.68	1,283	36.22	14.76	1,971	36.69	15.47
Log household size	1,059	1.53	0.39	930	1.46	0.52	557	1.59	0.42	1,422	1.52	0.49	1,283	1.55	0.40	1,971	1.50	0.47
Number of males > = 15 years in household	1,059	1.59	1.04	930	1.66	1.24	557	1.51	0.98	1,422	1.60	1.05	1,283	1.52	0.96	1,971	1.60	1.08
Number of females > = 15 years in household	1,059	1.50	0.79	930	1.50	0.83	557	1.34	0.68	1,422	1.43	0.77	1,283	1.49	0.79	1,971	1.47	0.82
Number of children < = 5 years in household	1,059	0.62	0.73	930	0.61	0.82	557	0.88	0.92	1,422	0.76	0.85	1,283	0.69	0.74	1,971	0.68	0.76
Area nonhomestead land	1,059	68.12	123.65	930	117.67	207.25	557	48.24	96.99	1,422	114.22	196.53	1,283	63.30	129.61	1,971	126.06	223.62
Area homestead land	1,059	15.78	15.82	930	17.05	18.83	557	10.15	10.56	1,422	14.06	16.38	1,283	14.28	21.08	1,971	21.03	36.95
Lead female some primary education	1,059	0.05	0.22	930	0.04	0.20	557	0.17	0.38	1,422	0.16	0.37	1,283	0.18	0.38	1,971	0.20	0.40
Lead female completed primary	1,059	0.05	0.22	930	0.05	0.23	557	0.02	0.13	1,422	0.03	0.17	1,283	0.03	0.17	1,971	0.02	0.15
Lead female some secondary	1,059	0.03	0.16	930	0.03	0.18	557	0.06	0.25	1,422	0.11	0.31	1,283	0.06	0.23	1,971	0.08	0.27
Lead female completed secondary	1,059	0.01	0.09	930	0.01	0.09	557	0.01	0.11	1,422	0.02	0.13	1,283	0.01	0.07	1,971	0.01	0.11
Lead female some university	1,059	0.01	0.08	930	0.02	0.12	557	0.00	0.00	1,422	0.01	0.09	1,283	0.00	0.03	1,971	0.00	0.07
B (technology pending) village	1,059	0.53	0.50	930	0.58	0.49	557	0.22	0.42	1,422	0.42	0.49	1,283	0.44	0.50	1,971	0.55	0.50

Table 10—Summary statistics for Saturia (vegetable site) census households (*A* versus *B* versus *C*)

	Adopter (*A*)			Likely adopter (*B*)			P-value *A* versus *B*	Non- and non-likely adopter (*C*)		
Variable	Observations	Mean	Standard Deviation	Observations	Mean	Standard Deviation		Observations	Mean	Standard Deviation
NGO member	350	1.00	0.00	195	1.00	0.00	n.a.	1,444	0.36	0.48
Adopter household	350	1.00	0.00	195	0.00	0.00	n.a.	1,444	0.00	0.00
Likely-adopter household	350	0.00	0.00	195	1.00	0.00	n.a.	1,444	0.00	0.00
Adopter or likely-adopter household	350	1.00	0.00	195	1.00	0.00	n.a.	1,444	0.00	0.00
Male-headed household	350	0.94	0.24	195	0.93	0.25	0.64	1,444	0.93	0.26
Age of lead male	350	39.62	14.79	195	38.32	15.79	0.33	1,444	40.48	16.97
Age of lead female	350	33.15	10.97	195	32.76	11.81	0.70	1,444	33.22	14.00
Household head is Muslim	350	0.93	0.26	195	0.93	0.25	n.a.	1,444	0.95	0.22
Lead male some primary education	350	0.09	0.28	195	0.04	0.20	**0.03**	1,444	0.07	0.26
Lead male completed primary	350	0.06	0.24	195	0.10	0.30	0.09	1,444	0.07	0.25
Lead male some secondary education	350	0.06	0.23	195	0.05	0.22	0.62	1,444	0.06	0.23
Lead male completed secondary	350	0.03	0.18	195	0.02	0.14	0.50	1,444	0.03	0.16
Lead male some university	350	0.08	0.28	195	0.05	0.22	0.20	1,444	0.08	0.27
Years reside in village	350	37.31	14.83	195	35.89	15.75	0.30	1,444	38.20	16.68
Log household size	350	1.51	0.37	195	1.53	0.40	0.56	1,444	1.49	0.48
Number of males > = 15 years in household	350	1.53	0.94	195	1.54	1.18	0.91	1,444	1.65	1.17
Number of females > = 15 years in household	350	1.47	0.75	195	1.52	0.86	0.48	1,444	1.50	0.81
Number of children < = 5 years in household	350	0.58	0.70	195	0.65	0.73	0.27	1,444	0.62	0.80
Area nonhomestead land	350	60.14	108.23	195	72.74	139.45	0.24	1,444	101.34	184.05
Area homestead land	350	15.82	16.05	195	16.22	14.86	0.77	1,444	16.53	17.89
Lead female some primary education	350	0.05	0.23	195	0.07	0.26	0.35	1,444	0.04	0.20
Lead female completed primary	350	0.05	0.21	195	0.06	0.24	0.61	1,444	0.05	0.22
Lead female some secondary	350	0.03	0.17	195	0.02	0.14	0.48	1,444	0.03	0.17
Lead female completed secondary	350	0.01	0.12	195	0.01	0.10	1.00	1,444	0.01	0.07
Lead female some university	350	0.02	0.13	195	0.00	0.00	0.03	1,444	0.01	0.10
B (technology pending) village	350	0.00	0.00	195	1.00	0.00	n.a.	1,444	0.63	0.48

Note: n.a. = not available.

Table 11—Summary statistics for Mymensingh (private fishpond site) census households (*A* versus *B* versus *C*)

	Adopter (*A*)			Likely Adopter (*B*)			P-value *A* versus *B*	Non- and non-likely adopter (*C*)		
Variables	Observations	Mean	Standard Deviation	Observations	Mean	Standard Deviation		Observations	Mean	Standard Deviation
NGO member	570	0.30	0.46	284	0.19	0.40	0.00	995	0.32	0.47
Adopter household	570	1.00	0.00	284	0.00	0.00	n.a.	995	0.00	0.00
Likely-adopter household	570	0.00	0.00	284	1.00	0.00	n.a.	995	0.00	0.00
Adopter or likely-adopter household	570	1.00	0.00	284	1.00	0.00	n.a.	995	0.00	0.00
Male-headed household	570	0.98	0.15	284	0.98	0.14	1.00	995	0.93	0.26
Age of lead male	570	42.97	14.07	284	45.10	15.97	**0.05**	995	37.04	15.95
Age of lead female	570	33.58	14.50	284	34.33	15.48	0.49	995	30.45	13.56
Household head is Muslim	570	1.00	0.18	284	1.00	0.00	1.00	995	0.97	0.18
Lead male some primary education	570	0.19	0.39	284	0.21	0.41	0.49	995	0.14	0.34
Lead male completed primary	570	0.02	0.14	284	0.01	0.12	0.30	995	0.01	0.10
Lead male some secondary education	570	0.15	0.35	284	0.21	0.41	**0.03**	995	0.06	0.24
Lead male completed secondary	570	0.08	0.28	284	0.07	0.25	0.61	995	0.02	0.15
Lead male some university	570	0.10	0.30	284	0.09	0.28	0.64	995	0.02	0.14
Years reside in village	570	42.03	14.14	284	43.82	16.07	0.10	995	35.72	15.06
Log household size	570	1.67	0.44	284	1.64	0.48	0.36	995	1.42	0.46
Number of males > = 15 years in household	570	1.82	1.11	284	1.83	1.10	0.90	995	1.32	0.82
Number of females > = 15 years in household	570	1.62	0.87	284	1.51	0.81	0.08	995	1.23	0.56
Number of children < = 5 years in household	570	0.77	0.89	284	0.78	0.92	0.88	995	0.82	0.84
Area nonhomestead land	570	150.43	214.99	284	188.42	224.77	**0.02**	995	28.99	89.84
Area homestead land	570	17.48	15.60	284	20.38	20.66	**0.02**	995	7.27	8.63
Lead female some primary education	570	0.22	0.41	284	0.19	0.39	0.30	995	0.12	0.33
Lead female completed primary	570	0.04	0.20	284	0.04	0.19	1.00	995	0.01	0.11
Lead female some secondary	570	0.16	0.37	284	0.15	0.36	0.71	995	0.04	0.21
Lead female completed secondary	570	0.03	0.17	284	0.02	0.16	0.41	995	0.01	0.08
Lead female some university	570	0.01	0.10	284	0.01	0.10	1.00	995	0.00	0.04
B (technology pending) village	570	0.00	0.00	284	1.00	0.00	n.a.	995	0.43	0.50

Note: n.a. = not available.

Table 12—Summary statistics for Jessore (group fishpond site) census households (*A* versus *B* versus *C*)

Variables	Adopter (*A*)			Likely adopter (*B*)			P-value *A* versus *B*	Non- and non-likely adopter (*C*)		
	Observations	Mean	Standard Deviation	Observations	Mean	Standard Deviation		Observations	Mean	Standard Deviations
NGO member	249	1.00	0.00	176	1.00	0.00	n.a.	2,822	0.30	0.46
Adopter household	249	1.00	0.00	176	0.00	0.00	n.a.	2,822	0.00	0.00
Likely-adopter household	249	0.00	0.00	176	1.00	0.00	n.a.	2,822	0.00	0.00
Adopter or likely-adopter household	249	1.00	0.00	176	1.00	0.00	n.a.	2,822	0.00	0.00
Male-headed household	249	0.96	0.21	176	0.89	0.32	**0.01**	2,822	0.97	0.18
Age of lead male	249	42.04	14.07	176	37.13	17.20	**0.00**	2,822	39.67	15.06
Age of lead female	249	33.53	11.77	176	32.76	11.76	0.51	2,822	31.49	13.21
Household head is Muslim	249	0.96	0.33	176	0.95	0.22	0.73	2,822	0.95	0.26
Lead male some primary education	249	0.18	0.39	176	0.17	0.38	0.79	2,822	0.20	0.40
Lead male completed primary	249	0.03	0.17	176	0.03	0.18	1.00	2,822	0.02	0.16
Lead male some secondary education	249	0.10	0.30	176	0.11	0.32	0.74	2,822	0.13	0.34
Lead male completed secondary	249	0.04	0.20	176	0.03	0.17	0.59	2,822	0.05	0.21
Lead male some university	249	0.02	0.13	176	0.02	0.13	1.00	2,822	0.03	0.18
Years reside in village	249	38.65	14.35	176	36.60	14.07	0.14	2,822	36.30	15.34
Log household size	249	1.59	0.40	176	1.52	0.43	0.09	2,822	1.51	0.45
Number of males > = 15 years in household	249	1.61	1.02	176	1.43	0.95	0.07	2,822	1.57	1.04
Number of females > = 15 years in household	249	1.60	0.87	176	1.52	0.76	0.32	2,822	1.46	0.81
Number of children < = 5 years in household	249	0.60	0.72	176	0.59	0.69	0.87	2,822	0.70	0.76
Area nonhomestead land	249	66.88	145.08	176	77.19	116.35	0.43	2,822	105.84	201.89
Area homestead land	249	17.84	28.57	176	14.38	18.56	0.16	2,822	18.68	32.76
Lead female some primary education	249	0.15	0.36	176	0.26	0.44	**0.00**	2,822	0.19	0.39
Lead female completed primary	249	0.04	0.20	176	0.04	0.20	1.00	2,822	0.02	0.15
Lead female some secondary	249	0.04	0.19	176	0.06	0.24	0.34	2,822	0.07	0.26
Lead female completed secondary	249	0.00	0.06	176	0.01	0.08	0.14	2,822	0.01	0.10
Lead female some university	249	0.00	0.00	176	0.00	0.00	n.a.	2,822	0.00	0.06
B (technology pending) village	249	0.00	0.00	176	1.00	0.00	n.a.	2,822	0.52	0.50

Note: n.a. = not available.

Table 13—Saturia: Bivariate Probit Regression of NGO membership and adopter and likely adopter of vegetable technology

Variable label	NGO member		Adopter or likely adopter	
	Coefficient	t-statistic	Coefficient	t-statistic
1 = male household head; 0=otherwise	0.396	**2.11**	0.503	**2.30**
Lead male's age	-0.003	-0.99	-0.011	**-2.66**
Lead female's age	0.006	1.78	0.008	**2.11**
1 = household head is Muslim; 0 = otherwise	0.027	0.21	-0.040	-0.30
1 = lead male some primary education; 0 = otherwise	-0.070	-0.61	-0.043	-0.35
1 = lead male completed primary; 0 = otherwise	0.013	0.11	0.043	0.35
1 = lead male some secondary education; 0 = otherwise	-0.043	-0.34	-0.011	-0.08
1 = lead male completed secondary; 0 = otherwise	-0.197	-1.08	0.039	0.20
1 = lead male some university; 0 = otherwise	-0.243	-1.75	-0.121	-0.80
Years resided in village	-0.004	-1.80	0.000	0.17
Log of household size	0.609	**5.95**	0.533	**4.86**
Number of male members over age 15 in household	-0.098	**-2.55**	-0.077	-1.81
Number of female members over age 15 in household	0.018	0.38	-0.019	-0.36
Number of children aged 5 or under in household	-0.119	**-2.88**	-0.104	**-2.36**
Area nonhomestead land in decimals	-0.002	**-6.48**	-0.001	**-4.46**
Area of homestead in decimals	0.001	0.72	0.002	0.94
1 = lead female some primary education; 0 = otherwise	0.212	1.57	0.338	**2.42**
1 = lead female completed primary; 0 = otherwise	0.048	0.35	0.013	0.09
1 = lead female some secondary; 0 = otherwise	0.080	0.42	-0.071	-0.34
1 = lead female completed secondary; 0 = otherwise	0.200	0.50	0.547	1.26
1 = lead female some university; 0 = otherwise	-0.142	-0.44	0.177	0.53
1 = dummy for *B* (technology pending) village; 0 = otherwise	-0.134	**-2.30**	-0.668	**-10.62**
Constant	-0.703	**-3.06**	-1.098	**-4.31**
athrho	10.24	0.08		
Rho	1.00			
Likelihood ratio text of rho = 0: chi2(1) = 847.476				
Prob > chi2 = 0.0000				
Number of observations = 1,989				
Wald chi2(44) = 698.74				
Prob > chi2 = 0.0000				
Log likelihood = -1,967.0546				

Table 14—Mymensingh: Bivariate Probit Regression of NGO membership and adopter or likely adopter of private fishpond technology

Variable label	NGO member		Adopter or likely adopter	
	Coefficient	t-statistic	Coefficient	t-statistic
1 = male household head; 0=otherwise	-0.058	-0.25	0.282	1.15
Lead male's age	0.001	0.17	-0.005	-1.24
Lead female's age	0.004	1.02	-0.005	-1.56
1 = household head is Muslim; 0 = otherwise	0.089	0.46	1.323	**3.78**
1 = lead male some primary education; 0 = otherwise	0.078	0.87	0.285	**3.25**
1 = lead male completed primary; 0 = otherwise	0.024	0.09	0.499	**2.01**
1 = lead male some secondary education; 0 = otherwise	-0.121	-1.03	0.509	**4.63**
1 = lead male completed secondary; 0 = otherwise	-0.314	-1.81	0.236	1.48
1 = lead male some university; 0 = otherwise	-0.471	**-2.29**	0.476	**2.65**
How many years in village	-0.008	**-2.54**	0.020	**5.89**
Log of household size	0.581	**5.47**	0.281	**2.76**
Number of male members over age 15 in household	0.025	0.56	-0.058	-1.37
Number of female members over age 15 in household	-0.113	**-2.08**	0.036	0.69
Number of children aged 5 or under in household	-0.039	-0.92	-0.027	-0.63
Area nonhomestead land in decimals	-0.002	**-6.00**	0.002	**6.23**
Area of homestead in decimals	-0.004	-1.16	0.015	**5.21**
1 = lead female some primary educ; 0 = otherwise	0.042	0.45	0.211	**2.34**
1 = lead female completed primary; 0 = otherwise	-0.169	-0.77	0.604	**2.84**
1 = lead female some secondary; 0 = otherwise	-0.037	-0.27	0.476	**3.82**
1 = lead female completed secondary; 0 = otherwise	0.250	0.87	0.319	1.17
1 = lead female some university; 0 = otherwise	-5.918	0.00	0.718	1.57
1 = dummy for *B* (technology pending) village; 0 = otherwise	-0.564	**-8.16**	-0.117	-1.79
Constant	-0.769	**-2.65**	-3.079	**-7.28**
athrho	0.07306	1.70		
Rho	0.07293			
Likelihood ratio test of rho = 0: chi2(1) = 2.90032 Prob > chi2 = 0.0886				
Number of observations = 1,979				
Wald chi2(44) = 594.12				
Prob > chi2 = 0.0000				
Log likelihood = -2,159.9593				

Table 15—Jessore: Bivariate Probit Regression of NGO membership and adopter or likely adopter of private fishpond technology

Variable label	NGO member		Adopter or likely adopter	
	Coefficient	t-statistic	Coefficient	t-statistic
1 = male household head; 0 = otherwise	0.025	0.14	-0.549	**-2.64**
Lead male's age	-0.002	-0.53	0.002	0.51
Lead female's age	0.001	0.43	-0.001	-0.29
1 = household head is Muslim; 0 = otherwise	-0.353	**-4.06**	0.002	0.02
1 = lead male some primary education; 0 = otherwise	-0.104	-1.66	-0.116	-1.47
1 = lead male completed primary; 0 = otherwise	-0.082	-0.57	0.092	0.53
1 = lead male some secondary education; 0 = otherwise	-0.161	**-1.99**	-0.181	-1.74
1 = lead male completed secondary; 0 = otherwise	-0.242	**-2.00**	-0.202	-1.29
1 = lead male some university; 0 = otherwise	-0.360	**-2.15**	-0.300	-1.33
How many years in village	0.002	0.77	0.004	1.45
Log of household size	0.513	**6.27**	0.376	**3.67**
Number of male members over age 15 in household	-0.081	**-2.49**	-0.077	-1.94
Number of female members over age 15 in household	0.057	1.53	0.083	1.82
Number of children aged 5 or under in household	-0.085	**-2.45**	-0.155	**-3.52**
Area nonhomestead land in decimals	-0.001	-1.18	0.001	0.49
Area of homestead in decimals	-0.001	**-6.90**	-0.001	**-4.22**
1 = lead female some primary education; 0 = otherwise	0.029	0.46	0.158	**2.03**
1 = lead female completed primary; 0 = otherwise	0.296	**2.02**	0.503	**3.01**
1 = lead female some secondary; 0 = otherwise	0.096	0.89	0.040	0.28
1 = lead female completed secondary; 0 = otherwise	-0.106	-0.38	0.048	0.13
1 = lead female some university; 0 = otherwise	-0.532	-0.95	-6.022	0.00
1 = dummy for *B* (technology pending) village; 0 = otherwise	-0.241	**-5.25**	-0.236	**-4.12**
Constant	-0.353	-1.75	-1.066	-4.61
athrho	2.234	**3.77**		
Rho	0.97716			
Likelihood ratio test of rho = 0: chi2(1) = 845.025 Prob > chi2 = 0.0000				
Number of observations = 3,254				
Wald chi2(44) = 267.54				
Prob > chi2 = 0.0000				
Log likelihood = -2,852.0184				

Table 16—Determinants of "*A*" (technology-recipient) versus "*B*" (technology pending) village status (probit marginal effects)

		dF/dx	z
Key technology NGO-related			
Distance to key NGO office	milesngo	0.05	0.65
Physical			
Distance to nearest paved road (kilometers)	howfar	0.12	1.13
Any household in village has electricity	electr	-0.35	**-1.73**
Village has a market	bazar	0.24	1.27
Minutes to nearest phone *(dropped--highly correlated with minutes to bus stop*)			
Minutes to nearest post office	postmin	-0.01	-1.16
Minutes to nearest bus stop	busmin	0.00	-0.46
Political			
Village has a Union Parisad representative (current or in past 5 years)	uprep	-0.30	-1.64
Social			
Number of mosques	nmosq	0.15	1.21
Village has a youth organization	youth	-0.08	-0.3
Number of 12 local NGOs with members in this village	orgs	0.00	0.06
Human			
Minutes to *thana* health center (wet season)	healws	-0.01	**-1.89**
Minutes to nearest pharmacy (wet season) *(dropped—highly correlated with minutes to* thana *health center*)			
ORS available in village (*dropped—highly correlated with minutes to* thana *health center*)			
Has a BRAC school	bracs	0.04	0.13
Has a primary school	prims	0.10	0.42
Has a secondary school	seconds	0.14	0.42
Has a *madrasa* school	mdras	0.23	1.07
Has adult education classes	adlts	0.21	1.01
Natural			
Value per decimal irrigated upland (1996 taka)	lnihigh	-0.05	-0.24
Value per decimal irrigated lowland (1996 taka) *(dropped—highly correlated with value of irrigated upland)*			
Tubewell as primary source for drinking water *(dropped—no variation)*			
Number of tubewells in the village	numtwell	**0.00**	-0.05
Other			
Village perceived to be richer than neighboring villages	richer	**0.13**	0.47
Number of observations		47	
LR chi2(19)		31.38	
Prob > chi2		0.0367	
Pseudo R2		0.4894	
Test of all parameters equal to zero			
Chi2(19)		12.32	
Prob > chi2		0.8716	

Note: Results slightly different from previous version because multicollinearity investigated more fully here.

Table 17—Household livelihood assets

	A households	*B* households	P-value on difference
Number of observations	321 households	318 households	
Physical capital			
Value of wife's assets at marriage	2,433.00	3,280.00	0.36
Value of husband's assets at marriage	86,668.00	80,288.00	0.67
Wife share of current household assets	0.06	0.06	0.97
Total value of household assets (1996 taka)	203,794.00	191,370.00	0.51
Value of durables	14,591.00	13,675.00	0.66
Value of house	2,899.00	1,655.00	0.02*
Value of land	180,212.00	169,766.00	0.56
Value of livestock	6,422.00	6,274.00	0.79
Household owns plow/other agricultural equip	0.55	0.62	0.08
Value of plow/other agricultural equip (1996 taka)	216.00	272.00	0.07
Land owned (acres)	1.55	1.44	0.48
Homestead area (acres)	0.16	0.15	0.16
Owns only homestead land, no fields	0.15	0.13	0.33
Cultivable crop area (acres)	1.26	1.20	0.68
Cultivable pond area (acres)	0.17	0.21	0.33
Land area leased in (acres)	0.12	0.19	0.11
Land area never flooded (acres)	0.65	0.52	0.1
Land area in *Boro* rice	1.04	1.15	0.26
Land area in Aus rice	0.79	0.66	0.06
Land area in *Aman* rice	1.09	1.04	0.57
Number of poultry	12.90	13.90	0.29
Number of sheep/goats	1.50	1.70	0.4
Number of dairy cows	1.00	1.00	0.28
Number of beef cattle	1.50	1.50	0.79
Uses closed pit or sanitary latrine	0.47	0.30	0.00*
Human capital			
Adult male (age 19-45 years) height (centimeters)	162.7	162.6	0.83
Adult female (age 19-45 years) height (centimeters)	151.04	150.12	0.03*
Percent of adult females (age 19-45 years) < 145 centimeters	33.5	39.2	0.12
Household size	5.80	5.60	0.45
Number of prime-age male earners	1.20	1.20	0.98
Household female headed	0.04	0.04	0.82
Laterally extended household	0.11	0.10	0.93
Vertically extended household	0.35	0.30	0.21
Percent of household members prime-age male earners	22.00	22.00	0.97
Highest male education attainment in household	6.00	5.20	0.01**
Highest female education attainment in household	4.20	3.60	0.02*
Dependency ratio	0.49	0.49	0.94
Financial capital			
Number of 3 rounds took a loan	2.10	2.00	0.26
Loan amount round 1 (1996 taka)	7,689.00	7,293.00	0.65
Social capital			
No food gifts given during year	0.50	0.48	0.5
No gift food or income received during year	0.35	0.38	0.36

Table 18—Female empowerment outcomes

		All sites			Saturia (vegetable site)			Mymensingh (private fishpond site)			Jessore (group fishpond site)		
		A households	B households	P-value	A households	B households	P-value	A households	B households	P-value	A households	B households	P-value
Visited friends/relatives outside of village in past year	visfrie	95	90	**0.05**	93	84	**0.05**	92	91	0.88	99	96	0.17
Gone to haat/bazaar in past year	vishaat	19	19	0.84	20	22	0.80	11	10	0.77	25	26	0.83
Attended NGO training or programs in past year	visngo	31	17	**0.00**	40	19	**0.00**	18	12	0.23	33	18	**0.02**
If sister outside of village, visited her in past year	cotsis	95	95	0.89	92	95	0.56	94	91	0.50	97	100	0.20
If brother outside of village, visited him in past year	cotbro	94	94	0.92	92	89	0.60	97	96	0.72	92	96	0.28
If son outside of village, visited him in past year	cotson	n.a.	n.a.		na	na		n.a.	n.a.		n.a.	n.a.	
If daughter outside of village, visited her in past year	cotdau	99	98	0.84	100	100	n.a.	100	97	0.34	96	100	0.49
Husband/family member verbally abused you in past year	d6	66	71	0.21	64	72	0.23	65	67	0.85	68	73	0.45
Husband/family member beat you in past year	d7	23	33	**0.01**	22	29	0.27	26	31	0.40	22	38	**0.02**
Woman knows name of UP chairman	namchairm	82	74	**0.02**	86	72	**0.02**	73	70	0.63	86	79	0.23
Woman knows name of her MP	nameMP	47	35	**0.00**	51	29	**0.00**	61	53	0.24	29	24	0.43
Woman knows name of Prime Minister	namePM	88	81	**0.02**	81	62	**0.00**	94	95	0.85	89	86	0.48
Woman has ever voted	vote	89	87	0.45	94	91	0.49	81	73	0.25	94	97	0.31
For last vote, woman chose who she voted for	selfvote	32	26	0.15	44	41	0.74	19	21	0.77	30	15	**0.01**
Worked for pay in past year	inc	70	67	0.38	60	60	0.98	63	53	0.14	89	88	0.80
Ever decides alone about family expenditures	dec_alon	45	50	0.20	22	29	0.26	18	23	0.42	98	99	0.57
Able to save money on her own for expenses/security?	ownsec	73	69	0.34	59	60	0.86	70	55	**0.03**	90	92	0.62
Husband/family member took money from you against your will in past year	d1	22	18	0.35	13	15	0.62	37	17	**0.00**	15	22	0.24
Husband/family member took asset from you against your will in past year	d2	11	7	0.12	11	8	0.47	9	1	**0.03**	12	11	0.80

Table 19—Marginal effects of predicted *A* village status (versus technology-pending *B* village status) on female empowerment outcomes (members of key NGO only)

	All	Saturia	Mymensingh	Jessore
Visited friends/relatives outside of village in past year	0.00	0.09*	0.03	0.00
Gone to haat/bazaar in past year	0.01	0.14*	0.02	-0.01
Attended NGO training or programs in past year	0.03	-0.25*	0.04	0.02***
If sister outside of village, visited her in past year	-0.07	-0.08	-0.03	-0.03
If brother outside of village, visited him in past year	0.06	0.26	0.03	0.04
If son outside of village, visited him in past year	n.a.	n.a.	n.a.	n.a.
If daughter outside of village, visited her in past year	-0.03	-0.02	0.04	-0.01**
Husband/family member verbally abused you in past year	-0.12	-0.16	-0.05	-0.29*
Husband/family member beat you in past year	-0.05	0.14	-0.13	-0.16
Woman knows name of UP chairman	-0.09	0.14	-0.02	-0.18
Woman knows name of her MP	-0.06	-0.22*	-0.05	-0.06
Woman knows name of Prime Minister	0.05	0.06	0.02**	-0.02
Woman has ever voted	0.03	-0.03	0.09	0.07
For last vote, woman chose who she voted for	-0.07	-0.10	-0.15***	-0.02
Worked for pay in past year	0.12*	-0.06	0.12	0.11***
Ever decides alone about family expenditures	-0.02	0.14	0.04	n.a.
Able to save money on her own for expenses/security?	0.12*	0.20	0.12	0.10*
Husband/family member took money from you against your will in past year	-0.06	-0.08*	-0.09	0.01
Husband/family member took asset from you against your will in past year	0.02	0.01*	-0.06**	0.05

Notes: *, **, *** denote statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. Probit regressions are weighted for sampling probabilities. Probit regressions include key NGO-member (*A* and *B*) households only. Marginal effects in this table are from 19 x 4 = 76 regressions; complete regression results available upon request from the authors.

Table 20—Livelihood outcomes

	A households	*B* households	P-value on difference
Household level			
Study-wide well-being status			
In 'bottom poor' well-being category	0.02	0.06	0.04**
In 'helpless poor' well-being category	0.15	0.13	0.33
In 'social poor' well-being category	0.28	0.24	0.20
In 'middle' well-being category	0.47	0.52	0.22
In 'rich' well-being category	0.07	0.06	0.66
Expenditure/consumption			
Mean per capita monthly household total expenditure	712	697	0.62
Mean percent monthly expenditure on food	68.90	68.80	0.87
Annual expend on hired labor for crops	1,662	2,073	0.05**
Annual expend on nonlabor inputs for crops	3,344	3,540	0.51
Annual expend on hired labor for ponds	180	72	0.00***
Annual expend on nonlabor inputs for ponds	63	34	0.04**
Annual total health expenditure	1,626	1,670	0.86
Annual expenditures on doctor visits	282	216	0.48
Zero expenditures on doctor visits	0.50	0.49	0.84
Annual expenditures on education	1,403	1,334	0.71
Zero expenditures on education	0.06	0.08	0.32
Income sources and amounts			
Percent of 9 income sources	4.47	4.20	0.00***
Any self-employment income (1 = yes, 0 = no)	0.63	0.57	0.12
Any salary income (1 = yes, 0 = no)	0.23	0.16	0.03**
Any rental income (1 = yes, 0 = no)	0.12	0.09	0.33
Any gift income (1 = yes, 0 = no)	0.65	0.62	0.37
Any asset/dowry income (1 = yes, 0 = no)	0.02	0.02	0.80
Any wage income (1 = yes, 0 = no)	0.46	0.43	0.35
Any crop income (1 = yes, 0 = no)	0.84	0.88	0.18
Any pond income (1 = yes, 0 = no)	0.52	0.45	0.10*
Any livestock income (1 = yes, 0 = no)	0.99	0.98	0.20
Total household annual income (1996 taka)	38,559	35,654	0.32
Annual household farm income	16,380	14,529	0.20
Crop profit	11,309	10,382	0.43
Pond profit	2,527	1,365	0.00***
Livestock profit	1,796	2,069	0.36
Annual household off-farm income	18,144	16,103	0.19
Self-employment income	10,321	9,208	0.39
Salary income	3,833	3,510	0.73
Rental income	637	923	0.40
Gift income	3,212	3,689	0.78
Asset/dowry income	186	411	0.34
Wage income	3,989	3,385	0.25

(continued)

Table 20 (continued)

	Individuals in *A* households	Individuals in *B* households	P-value on difference
Individual-level			
Number of household observations	321 households	318 households	
Nutrient intakes			
Age 2-4.9: total calories—all	1,056	1,051	0.87
Age 2-4.9: total calories—boys	1,068	1,065	0.95
Age 2-4.9: total calories—girls	1,047	1,039	0.86
Age 2-4.9: percent calories animal sources—all	5.5	4.5	0.06*
Age 2-4.9: percent calories animal sources—boys	6.6	5.5	0.24
Age 2-4.9: percent calories animal sources—girls	4.7	3.7	0.12
Age 2-4.9: percent calories nonstaple plants—all	18.0	18.2	0.88
Age 2-4.9: percent calories nonstaple plants—boys	18.6	16.3	0.13
Age 2-4.9: percent calories nonstaple plants—girls	17.5	19.6	0.14
Age 5-9.9: total calories—all	1,576	1,600	0.42
Age 5-9.9: total calories—boys	1,613	1,659	0.27
Age 5-9.9: total calories—girls	1,531	1,535	0.93
Age 5-9.9: percent calories animal sources	3.3	3.1	0.52
Age 5-9.9: percent calories animal sources—boys	3.1	3.1	0.86
Age 5-9.9: percent calories animal sources—girls	3.5	3.2	0.50
Age 5-9.9: percent calories nonstaple plants	15.5	14.5	0.05**
Age 5-9.9: percent calories nonstaple plants—boys	15.6	14.3	0.06*
Age 5-9.9: percent calories nonstaple plants—girls	15.3	14.7	0.38
Age 10-17.9: total calories—all	2,245	2,206	0.14
Age 10-17.9: total calories—boys	2,405	2,388	0.67
Age 10-17.9: total calories—girls	2,072	1,998	0.04**
Age 10-17.9: percent calories animal sources	2.8	2.8	0.57
Age 10-17.9: percent calories animal sources—boys	2.9	3.0	0.66
Age 10-17.9: percent calories animal sources—girls	2.7	2.7	0.73
Age 10-17.9: percent calories nonstaple plants	14.6	13.9	0.02**
Age 10-17.9: percent calories nonstaple plants—boys	14.6	13.6	0.02**
Age 10-17.9: percent calories nonstaple plants—girls	14.6	14.3	0.46
Age 18-44.9: total calories—all	2,657	2,682	0.34
Age 18-44.9: total calories—men	3,031	3,126	0.01***
Age 18-44.9: total calories—women	2,305	2,274	0.26
Age 18-44.9: percent calories animal sources—all	2.9	2.8	0.62
Age 18-44.9: percent calories animal sources—men	3.1	3.1	0.97
Age 18-44.9: percent calories animal sources—women	2.6	2.6	0.48
Age 18-44.9: percent calories nonstaple plants—all	14.9	14.8	0.69
Age 18-44.9: percent calories nonstaple plants—men	14.6	14.9	0.44
Age 18-44.9: percent calories nonstaple plants—women	15.1	14.7	0.22
Age 45-99.9: total calories—all	2,412	2,468	0.12
Age 45-99.9: total calories—men	2,734	2,824	0.06*
Age 45-99.9: total calories—women	2,014	2,059	0.27
Age 45-99.9: percent calories animal sources—all	3.2	3.6	0.01***
Age 45-99.9: percent calories animal sources—men	3.4	3.9	0.02**
Age 45-99.9: percent calories animal sources—women	2.9	3.2	0.12
Age 45-99.9: percent calories nonstaple plants—all	15.6	14.9	0.04**
Age 45-99.9: percent calories nonstaple plants—men	16.3	15.4	0.07**
Age 45-99.9: percent calories nonstaple plants—women	14.9	14.4	0.35

(continued)

	Individuals in *A* households	Individuals in *B* households	P-value on difference
Nutrition outcomes			
Age 0-4.9: height-for-age Z-score—all	-2.16	-2.16	0.98
Age 0-4.9: height-for-age Z-score–boys	-2.03	-2.07	0.67
Age 0-4.9: height-for-age Z-score–girls	-2.30	-2.23	0.49
Age 5-9.9: height (centimeters)—all	113.9	113.0	0.07*
Age 5-9.9: height (centimeters)–boys	113.9	113.6	0.64
Age 5-9.9: height (centimeters)–girls	113.8	112.3	0.04**
Age 10-17.9: height (centimeters)—all	143.1	141.2	0.00***
Age 10-17.9: height (centimeters)–boys	144.6	142.2	0.00***
Age 10-17.9: height (centimeters)–girls	141.5	140.2	0.02**
Age 18-44.9: BMI–men	19.0	18.9	0.70
Age 18-44.9: BMI–women	19.0	19.3	0.11
Age 45-99.9: BMI–men	19.6	18.8	0.11
Age 45-99.9: BMI–women	20.1	20.3	0.85
Acute illness (days ill past two weeks)			
Age 0-4.9—all	3.8	4.3	0.04**
Age 5-9.9—all	2.0	2.2	0.25
Age 10-17.9—all	1.1	1.1	0.96
Age 18-44.9—all	1.6	1.5	0.33
Age 45-99.9—all	2.0	2.3	0.07*
Chronic illness (days ill in past one year)			
Age 0-4.9—all	48	79	0.00***
Age 5-9.9—all	74	74	0.97
Age 10-17.9—all	81	79	0.79
Age 18-44.9—all	99	124	0.00***
Age 45-99.9—all	136	161	0.00***

Table 21—Effects of predicted *A* village status (versus technology-pending (*B*) village status) on household expenditure, income, and child nutritional status (members of key NGO only)

	All	Saturia	Mymensingh	Jessore
Per capita annual household expenditure	-8.71	9.55	-27.58	11.34
Total annual household expenditure	64.02	222.61	-82.20	107.23
Total annual household income (all sources)	3,928.99	-236.84	4,895.34	8,240.22**
Total annual household farm income	4,701.87***	3,561.09	7,254.59***	2,973.97
Total annual household off-farm income	3,526.34*	2,468.58	2,432.26	5,985.30**
Total annual crop profit	3,467.90***	3,266.42	3,886.13**	3,720.40
Total annual pond profit	1,277.88***	-256.92	3,163.33***	-266.69
Height-for-age Z-score (children age 0-5 years)	0.21	1.20***	0.14	0.12
Height-for-age Z-score (girls age 0-5 years)	0.11	0.32	0.33	0.02
Height-for-age Z-score (boys age 0-5 years)	0.12	1.07**	0.01	-0.49
Body mass index (women age 18-49)	0.31	-0.27	-0.62	1.96*
Body mass index (men age 18-49)	0.14	0.08	.013	0.38
Weight (kilograms - women age 18-49)	-0.17	-2.35	-0.05	1.43
Weight (kilograms - men age 18-49)	-0.59	-0.20	-1.43	0.95

Notes: *, **, *** denote statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. Regressions are weighted for sampling probabilities. Regressions include key NGO-member (*A* and *B*) households only. Coefficients in this table are from 14 x 4 = 56 regressions; complete regressions results available upon request from the authors.

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