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No. 13

An Approach to Technological Innovation that Benefits Rural Women:

The Resource-to-Consumption System

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AN APPROACH TO TECHNOLOGICAL INNOVATION

THAT BENEFITS RURAL WOMEN:

THE RESOURCE-TO-CONSUMPTION SYSTEM

Susan K. Kaaria and Jacqueline A. Ashby

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OVERVIEW

Persistent rural poverty is rooted in the impoverishment of women. Not only are women a growing proportion of the rural poor, but also the welfare of children and overall household food security in poor countries are vitally affected by the women's access to resources and technology for food production and income generation. The incidence of poverty among women is growing. Since the 1970s the percentage of rural women below the poverty line has increased by 50% in contrast to 30% for men. Currently, women comprise nearly 60% of the world's one billion poor; and of the more than 300 million living in absolute poverty, women represent 70%. New challenges must be faced in view of the "*feminization of poverty,"* a trend that is driving rural women in particular to form an increasing proportion of the very poor, and the globalization of the world economy, which is changing the face of peasant agriculture.

This paper presents a critical review of the literature on efforts to benefit rural women through technological innovation in agriculture. The objective was to identify key factors leading to meeting the challenge of developing technologies that benefit specific beneficiary groups, such as women, successfully. We examine and compare different approaches that have been applied for technological innovation in agriculture, where women have benefited or have been impacted negatively in an attempt to derive working principles to guide future efforts.

As a result, we developed the concept of a "resource-to-consumption system" as an approach that brings together the main elements of the production-to-consumption chain used by successful approaches, but with the addition of the dimension of natural resource management by women. The findings corroborate that if new opportunities for technical innovation are to benefit poor rural women, they must link the following three goals:

- ⇨ Increase returns to women's labor and their independent income through the integration of nontraditional crops and products into female production and postharvest processing activities. A necessary condition for this goal is the development of complementary laborsaving technologies in low-return activities, especially where women do not control the products.
- ⇨ Build a strong association between agricultural intensification with nontraditional crops and products and increasing the capability of women to rehabilitate the natural resource base on which this intensification depends. Of particular importance is women's capacity to rehabilitate degraded soils through investment in improved integrated nutrient management (INM) technologies appropriate for and accessible to women producers.
- ⇨ Integrate both pre- and postharvest (including agro-processing) activities because the threats, opportunities and challenges need to be seen in the "Resource-to-Consumption System" context, from "farmer to dinner plate."

1 BACKGROUND

Thirty years after Ester Boserup's seminal work (1970) highlighting women's contributions to national economies, they still live under conditions of persistent rural poverty and food insecurity, gaining subsistence from some of the most degraded land. Furthermore, emerging trends in globalization of the world economy and male out-migration are transforming the traditional pattern of intra-household rights and obligations, increasing the number of women living in extreme poverty, leading to what has been called the "f*eminization of poverty*."

In developing countries the number of rural women living in poverty is estimated at 565 million; in Africa alone this figure is 30 million (UNDP 1995). Women comprise nearly 60% of the world's one billion poor, and of the 300 million living in absolute poverty, women represent 70% (UNIFEM 1999). The incidence of poverty among women is growing: Census data demonstrate that since the 1970s the percentage of rural women below the poverty line has increased by 50% in contrast to 30% for men (UNDP 1995).

Box 1. The "Feminization of Poverty"

Women are:

- 60% of the world's 1 billion poor
- 70% of the absolute poor
- 565 million rural women live in poverty in developing countries, 130 million in Africa
- Since the 1970'ties, 50% increase in percent of women below the poverty line, men 30%

New and emerging trends in the globalization of the world economy—such as the liberalization of trade and markets for food and other agricultural products, privatization of resources and services, and the commercialization and modernization of agriculture—may compound the impoverishment of women. Globalization poses a new threat by marginalizing some regions, countries or groups within countries, especially women (ECA 1998). For example, women's small businesses, which in many instances cannot compete with cheap imported products brought in by trade liberalization, will be crowded out (UNIFEM 1999). In Africa, women's traditional cottage industries such as food processing and basket weaving may be threatened. Similarly, in Asia, where new opportunities for employment are being created, women often receive low wages and work under poor conditions (UNIFEM 1999). Other emerging trends such as the breakdown of traditional family structures and support mechanisms, the rising mortality due to HIV/AIDS, the increasing number of refugees and rural male out-migration have had extensive impact on the magnitude of women's poverty (FAO 1999).

The impoverishment of women has immense implications for child nutrition, health and, consequently, their wellbeing. In many instances expenditure patterns of women's income share are usually associated with child-oriented goals such as increased health and education (Peña et al. 1996). In Guatemala empirical research found that there were stronger correlations between pre-schooler weight-for-age and height-for-age and mothers' incomes relative to fathers' incomes

(Engle 1991). A similar study in Brazil found that the probability of child survival is nearly 20 times greater when unearned income is earned by women rather than men (Thomas 1990).

Despite collective R&D efforts to improve their status, rural women are still highly over-represented amongst the poorest percentile. Consequently, it seems appropriate to ask why the feminization of poverty remains a global phenomenon and why economic growth has been accompanied by worsening poverty and inequality among poor rural women:

- ⇨ The failure of economic growth to support women's empowerment can be traced to widespread gender inequality, growing dependence on input intensive agricultural production, structural adjustment programs that cut deeply into rural services, and environmental degradation stemming from ineffective management of natural resources (ICGARDE 1999).

- ⇨ Women food producers face different challenges from men. Women have higher illiteracy levels; they lack access to and control over land, capital and credit markets and, thereby, inputs; there has been widespread and systematic sexual discrimination against women in agricultural delivery systems; and they have limited access to nonfarm labor markets because of their lack of education and mobility (Gladwin 1991; ECA 1998).

- ⇨ Empirical research demonstrates that women have not gained as well as men from technical change; in fact in numerous cases women were left worse off after the introduction of new technology.

Numerous studies have demonstrated that the impacts of technical change in agriculture have not been uniform and that in many instances the situation of women has worsened. This section briefly reviews literature on technology development in agriculture to examine the impacts of technical change on women's welfare. In the bulk of the cases negative impacts were identified. Several reasons can be attributed to the failure of technical change to impact positively on poor rural women:

(a) The assumption that technologies are "gender-neutral" is a key factor in explaining women's inability to benefit from improved technologies. For instance, research in Asia (Java and Bangladesh) showed that women were negatively impacted by the centralized industrialization and mechanized agriculture to a greater extent than men (Begum 1985; Kumar 1985; Scott and Carr 1985; Buvinic and Mehra 1990).
(b) Women are constrained from adopting the technology because of certain inherent characteristics: high labor and capital requirements or they are not included in the training and technology transfer activities (Kumar 1985, Gladwin et al. 1997).
(c) Technical change that does not consider the impacts of intra-household decision-making and the complex dynamics of resource allocation within the household can make women worse off (Kumar 1985; Alderman et al 1995; Buvinic and Mehra 1990). For example, technology to commercialize rice production—a woman's crop in Gambia— resulted in a shift in the control of the rice crop to men, making women worse off (Dey 1982; Carney 1992; von Braun and Webb, 1989).

The introduction of high-yielding maize varieties (HYV) with processing and cooking storage qualities different from the traditional varieties meant that the HYVs could not be adopted

integrally into the system (Doss 1996). Jiggins (1986) provides another illustration of the direct effects of technical change: the introduction of hybrid dent maize varieties in Malawi, where the people eat only the traditional flint types, which yield fine white flour. A similar example is the introduction of exotic cassava varieties in Zambia, without due consideration of the utilization of the biomass, in a region where cassava leaves were the main and sometimes only source of green vegetables (Jiggins 1986).

Buvinic and Mehra (1990) and Kumar (1985) compared empirical studies in smallholder farming systems to understand the indirect impacts of technical change on women's welfare. In the mid-1960s short-statured, fertilizer responsive HYVs were introduced in Asia. In many instances this mean increased labor use in women's tasks (uprooting, transplanting, weeding, etc) and resulted in an increase in women's workload and worsening their situation (Agrawal 1984; Acharya and Patkar 1983; Begum 1985; Amoloza 1998). In comparable work in Africa, the introduction of new technologies—irrigated rice, cocoa and cotton—increased demand on women's labor, or there was a shift of their labor from food production (Guyer 1980; Dey 1982; Jones 1986; Von Braun and Webb 1989, Carney 1992; Lilja and Sanders 1998). In the Africa example, there was either a corresponding loss of women's crop production role to men, an improvement in crops grown by men or a loss of subsidiary economic activities for women.

Given the differential impacts of mechanical technology, their indirect effect should be evaluated separately for different categories of women: landless, landed women, wage earners and food producers. For example, the mechanization of postharvest operations in Bangladesh reduced labor input and increased leisure in large- and small-landed households. On the other hand, it displaced labor, thereby reducing income and employment, for landless females, who unlike the men were not offered training or alternative employment (Begum 1985; Kumar 1985). In general the impact of technological innovation that did not consider women's concerns has had three broad effects: New technology shifted the distribution of resource control within households with possible negative welfare consequences on women. Technical innovation, especially the highly intensive green revolution technology, increased women's workload; while mechanized technology displaced poor landless women who were wage earners. By appropriating women's labor for production controlled by men, technical change reduced women's income and income-earning opportunities, thereby lowering household nutritional status indirectly.

The foregoing discussion raises several pertinent questions associated with transforming the extent of poverty among rural women:

- How can we develop technical innovation that will benefit women?
- Is it useful to invest in technological innovation that specifically targets women?
- What have been the successful technology development paths and what were the characteristics of technologies that impacted positively on women’s welfare?
- What were the characteristics of technologies that did not impact positively on women’s welfare?

This paper employs a case study approach to address these questions. The four case studies included here have been chosen to reflect the broader experiences of different types of approaches for developing technologies for women. This paper draws on both early work and the more recent research on technical innovation in agriculture to address the questions of how we can develop technologies to impact positively on poor rural women.

1.1 OBJECTIVES

This paper reviews literature on technological innovation in agriculture to derive lessons on the challenges of developing technologies that benefit a specific beneficiary group—women. The specific objectives are to:

- ⇨ Examine different approaches that have been applied to technological innovation in agriculture to benefit women specifically and identify critical factors contributing to a positive or negative outcome for women.
- ⇨ Compare the different approaches—developing technology **for** women vs taking a gender-sensitive approach in technology development that is not intended for a specific beneficiary group.
- ⇨ Identify the knowledge gaps, innovation opportunities and challenges in developing technologies for a specific beneficiary group such as poor rural women.
- ⇨ Recommend strategies as to how international agricultural R&D entities might approach the objective of providing appropriate technologies for a specific beneficiary group such as poor rural women.

2 CONCEPTUAL FRAMEWORK

Figure 1 presents the framework developed and used to focus this study and the review of literature on the impact of technological innovation on women's welfare. We identified issues that are important to international research and those that are important to women. In this context investments by the CGIAR (Consultative Group on International Agricultural Research) (Appendix 1) were used to represent the broader interests within international agricultural research. On the other hand, issues that are important to women were identified by defining those spheres that women control, determined as follows:

- ➢ women manage the use of the product (process and sales)
- ➢ women have ownership rights to the output, traditionally, and
- ➢ they rely on the crop for food security

Five broad areas (Fig. 1 A-E) were identified. Groups A-C represent areas of high investment by international agricultural research; in contrast, Groups D and E are areas of low investment. Groups D and B represent areas of high importance to women. The framework shows that in several instances issues that are important in the international research arena are different from those that are important to women.

Building on these findings, a preliminary review of literature on technology development in these groups was conducted to identify the specific case studies analyzed in this paper. Case studies were selected on the basis of there being a technology development experience with women as beneficiaries in the area and that it would contribute different lessons and perspectives to this paper.

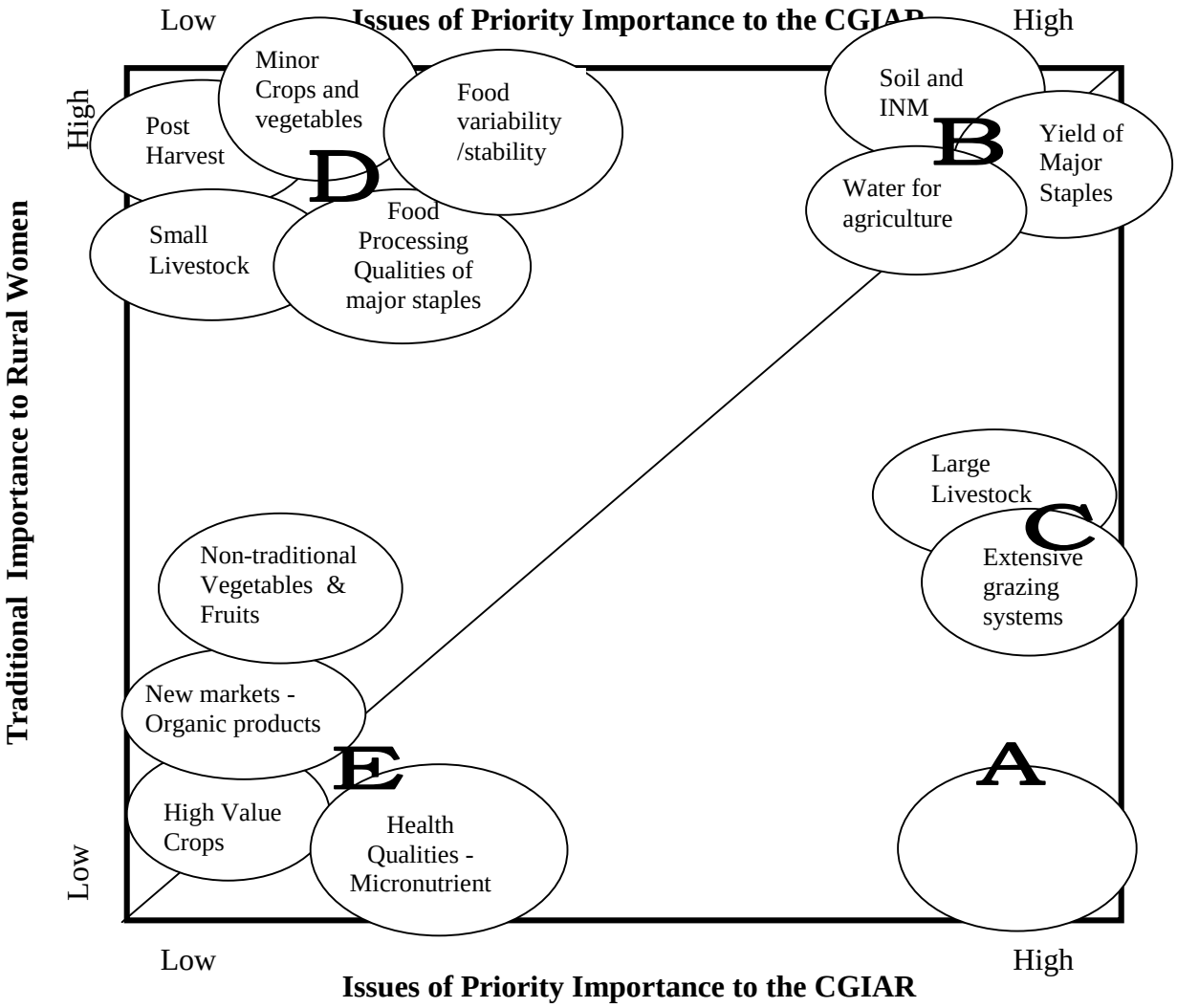

Figure 1. Framework for assessing welfare impacts and new opportunities.

2.1 SELECTION OF RESEARCH AREAS AND APPROACHES TO TECHNOLOGY DEVELOPMENT

A review of the literature identified different approaches that have been used to integrate gender concerns into technology development and areas where there is experience in technology development with women as the beneficiaries, and guided the selection of case studies. Table 1 summarizes the approaches and case studies selected in this study. The cases selected provide a broad range of experiences with respect to technology development with women as beneficiaries.

The first two approaches reviewed represent commodity research in major staples, representing Group A (Fig. 1), where different strategies were used to integrate gender concerns in technology

development. In both approaches, rice, was selected for review, and to develop an understanding of the impact of commodity research approaches on women's welfare. Rice was selected for several reasons: Firstly, both international and national agricultural research systems invest heavily in R&D in this commodity. For example, the CGIAR invests 17.3% (Appendix 1) of their total budget in rice farming systems (TAC 2000). Secondly, rice is one of the few commodity crops with extensive experience and research work in developing technologies with women as a beneficiary group. No cases were selected from Group E because documented experiences with a strong research component in low-income countries are scanty in this group and would have thus provided insufficient experience and lessons.

Table 1. Cases selected - Linking research areas to approaches.

Research Areas	**Approaches**			
	Commodity Technology Transfer	**Systems Research Targeting Women**	**WID[1] Project Component**	**Improving Assets**
Commodity research - major staples	Case Study 1	Case Study 2		
Women's traditional tasks - food processing			Case Study 3	
Integrated nutrient management (INM)				Case Study 4

2.2 THE APPROACHES

- *Commodity Technology Transfer Approach* - the Irrigated Rice Schemes in Gambia (Jahaly Pacharr project) are used to derive lessons from this approach to technical change.
- *Systems Research Targeting Women* - the Women in Rice Farming Systems (WIRFS) program was also selected as an example to derive lessons of technology development in commodities specifically targeting women.
- *WID Project Components: adapting postharvest technology for women* - Postharvest/ processing technology was selected as the third case study. This example from Group D (Fig. 1) represents issues and products that are high-priority areas for women but low priority for international agricultural research system. Thus the bulk of the work in this area has been conducted outside the system and has focused on developing technologies for women's traditional tasks and responsibilities.
- *Improving Assets: INM technology development* - Although there is limited experience with technology development for women in this area, INM (Group B, Fig. 1) was also selected for review because of its implications for increasing agricultural productivity. This area offers new opportunities for women through improved management of soil nutrients and introduction of high-value products (HVPs), amongst others. The examples reviewed in this case study are on technology development for soil fertility management.

[1] WID - Women in Development

3 METHODOLOGY

3.1 THE APPROACHES AND THEIR CORRESPONDING CASE STUDIES

This section develops the approaches and the corresponding case studies identified for review: Commodity Research with Technology Transfer, Systems Research Targeting Women, WID Project Components - Adapting Postharvest Technology for Women, and Improving Assets - INM technology development. The selected case studies were grouped under these four approaches and compared to develop insights on the technology development process where R&D set out to design/situate technologies specifically to benefit women. The case studies represent different approaches for integrating gender into the technology development process. In some of the cases reviewed, the technology development process set out specifically to develop technologies for women or a gender-sensitive R&D strategy was used. In other instances gender considerations were not initially integrated, but the technology development process later incorporated a WID component to increase women's participation. These cases are drawn from examples in three continents: Sub-Saharan Africa, Asia and Latin America and the Caribbean. First a brief introduction is presented on the role of women in rice farming systems to set the context for discussing the first two approaches (Commodity Technology Transfer and Systems Research Targeting Women), which both address the impact of technical change in rice farming systems.

3.1.1 The context: Role of women and their needs for technology in rice farming systems

Rice is one of the few commodity crops where a substantial effort has been made to develop technologies with women as a beneficiary group. A comparative analysis of the two case studies developed here provides a useful discussion on how the technology development path chosen can have very diverse impacts for two projects with broadly similar objectives.

Appendix 2 presents a summary of women's roles in rice farming systems. It is evident that women make substantial contributions to these systems in both Asia and Africa. Although rice is managed and controlled by men in Asia, women are actively involved in the farming and contribute from 33% (in Indonesia) to 80% (in India) of the labor (Amoloza 1998).

It is also evident that a majority of their roles are laborious and time-intensive. Asian women are predominantly responsible for seed selection and storage, uprooting and transplanting, weeding, harvesting and postharvest processing (Appendix 2). For example, surveys conducted to examine the role of women in production of glutinous rice varieties show that women are involved in parboiling, hand-pounding (dehulling of grains - which requires physical strength), winnowing and marketing (Paris 2000). These are all tasks that are relatively labor intensive, strenuous and time-consuming. This underscores the need for laborsaving technologies to reduce labor burdens for women, who work on their own farms.

Similarly, women in West Africa are actively involved in rice production, providing from 3% (Mali) to 80-100% (Gambia and Liberia) of the labor requirements (Nyanteng 1985). Women are responsible for preparing land in swampy areas, uprooting and transplanting, weeding, scaring birds, harvesting and postharvest processing. In both Gambia and Cote d'Ivoire women initially grew rice on their own plots and controlled the benefits—before the introduction of rice irrigation

schemes. In Gambia there were clear distinctions of crops into men's and women's. Rice was considered a woman's crop, and they controlled more than 90% of the traditional rice fields, mainly swampland.

In both regions, women face several constraints to increasing their productivity in these rice-farming systems:

- ⇨ Labor for backbreaking, time-intensive, manual operations on land owned by others, mainly through unpaid family labor and/or wage labor (usually for lower wages than men receive).
- ⇨ Lack of information on crop management, postharvest storage and seed management
- ⇨ Large amounts of labor for intensive postharvest processing (dehulling, milling, etc), including household food preparation and processing to make alternative products for sale.

Therefore, to increase women's productivity, technology must: Firstly, increase women's access to information on management, postharvest storage and seed management, and build on women's knowledge of breeding, seed production and storage. Secondly, develop labor-saving technologies for women's back-breaking work with low returns (uprooting, transplanting, weeding and postharvest processing). Thirdly, incorporate strategies to ensure that women have access to the technologies. Finally, improve women's access to existing equipment such as small harvesters and threshers.

3.2 COMMODITY TECHNOLOGY TRANSFER APPROACH

To develop insights regarding the impact of this approach on women's welfare, we used the lessons from the irrigated rice schemes in Gambia. These case studies are well documented, with various reports that examine the impact of the commoditization of a "woman's crop" on their labor and crop rights, food consumption and nutrition, and on their welfare, in general. This discussion draws extensively from several empirical studies: Dey (1982); Jones (1986); Kumar (1985, 1987); Carney (1992); von Braun and Webb (989); von Braun et al. 1989; von Braun et al. (1989); and von Braun et al. (1994). Although the Gambia case study is at the extreme end on the continuum of projects that have affected women adversely, it is used here because it provides a good basis for comparison with other more recent approaches.

Box 2. Commodity Technology Transfer

Entry point: technology transfer
- ➢ Increased women’s workload and drudgery
- ➢ Women’s labor productivity 70% below men’s
- ➢ Women lost rights
- ➢ Increased total household income and calorie consumption

From 1966-1987, several aid missions were involved in implementing rice irrigation schemes in Gambia, with the objectives of raising yields and commercializing rice production in West Africa: Taiwan (1966-1974), World Bank (1973-76), the People's Republic of China (1975-1979), and the IFAD/AFDB/WFP (Jahaly Pacharr project) (1984-1987). This discussion focuses

on the World Bank Agricultural Development Project (ADP) and the IFAD (International Fund for Agricultural Development) programs, which unlike their predecessors, had an added objective of raising the women's share of household income.

The primary objectives of the irrigated rice schemes were to increase production of this staple food by cultivating rice for two seasons through irrigation, thereby producing a marketable surplus. The projects involved the installation of large-scale pumps to increase rice yields and intensify production by growing a rice crop in both the wet and dry seasons. The project also aimed to increase equity by focusing on a crop traditionally controlled by women. Because rice was traditionally a woman's crop, the projects specifically endeavored to ensure that gender considerations were integrated during the implementation phase. Project management proposed that irrigation plots should be registered in the name of the head women of each household.

Despite donor attempts to ensure that women retained control and benefited from the new technology, irrigated rice became a male-controlled crop. The projects failed to meet these goals because commoditization of rice introduced significant changes in the household resource allocation. The introduction of technology innovation affected the household division of labor, household production, land and crop rights, access to and allocation of household resources.

Two other irrigation projects in Cameroon and Cote de Voire, where rice was also introduced as a cash crop, will be reviewed to augment the information on Gambia. In the irrigated rice project in Cote de Voire, the new technology was supposed to increase the intensity of rice cropping. In this region women planted rice in the lowland areas (*dambos*), which retain moisture in the dry season; and, the men were involved in the cultivation of rainfed maize, yams and rice. Women had minimal obligations to help their husbands on their plots; however, these obligations increased significantly after project initiation. The introduction of new technology did not lead to increased rice production, as expected, because the women were unwilling to contribute their labor in an enterprise that represented no additional returns for them.

The irrigated rice project in Cameroon was also introduced as a cash crop in the 1980s. In this region women were traditionally involved in growing sorghum as the source of food on their own plots assigned to them by the heads of households. The women had control over their sorghum grain harvests and would at certain times also sell small quantities to purchase other household requirements. Traditionally, women had minimal obligations to work in the communal areas or in men's fields. In the project implementation stage women were also assigned rice plots; however, with the introduction of the new technology, they were required to help in their husbands' plots because of the high labor requirements. As a result less sorghum was grown because rice cultivation requirements conflicted with those of sorghum.

3.3 SYSTEMS RESEARCH-TARGETING WOMEN APPROACH

The Women in Rice Farming Systems (WIRFS) program is used as a case study to draw the lessons on the impacts of using a Systems Research-Targeting Women Approach to develop technologies, on women's welfare. Although this case study is not as well documented as the above approach, this analysis will endeavor to draw some lessons from the scanty evidence and from anecdotal studies. The discussions developed here are based on several reports on the

International Rice Research Institute's (IRRI) WIRFS program, Paris[2] (2000); Amoloza (1998); Bautista et al. (1994); Hlaing 1994; and Paris et al. (1994). The WIRFS program was developed under the umbrella of the Asian Rice Farming Systems Network (ARFSN) at IRRI. WIRFS' objectives were as bold as they were ambitious: Institutionalize gender concerns within conventional agricultural research and extension programs for rice farming systems by: Documenting the roles and activities of men and women in the rice farming systems and identify gender differences in access to resources. Designing, testing, evaluating and facilitating the adoption and dissemination of women-friendly technologies that alleviate drudgery, increasing labor productivity and contribute to income. Finally, by promoting and institutionalizing mechanisms to ensure women's participation in technology development.

The Systems Research-Targeting Women Approach differed from the Commodity Technology Transfer approach in several aspects:

- ⇨ It took into account women's needs and constraints as a starting point.
- ⇨ Women were involved in all aspects of technology development, from research to technology transfer.
- ⇨ The emphasis on increasing women's labor productivity and reducing drudgery by addressing women's constraints across the entire commodity chain. For example, the introduction of a higher yielding glutinous rice variety (IR65) and complementary laborsaving mechanical technology for processing concurrently addressed constraints to drudgery and labor productivity. This resulted in higher yields and production, as well as independent income accruing to women from processing and selling rice delicacies (Paris 2000).

Box 3. Systems Research Targeting Women

Entry point: womenn's needs and constrains

- ➢ Workload and drudgery decreased
- ➢ Labor productivity increased
- ➢ Ensured control over key assets
- ➢ Impact on independent income not documented.

In their ten years (1986-1996) of operation, the WIRFS program developed a wide array of technologies, ranging from a high-yielding glutinous rice varieties for making traditional sweetmeats to mechanical technologies (to reduce drudgery and increase labor productivity) such as the portable rice mill. Appendix 3 provides a summary of rice and rice-related technologies tested at key farming systems research sites, by country.

[2] The paper draws on her unpublished thesis research, " Bringing women farmers from the margin to the mainstream of rice research and technology development: Strategies and lessons learned." IRRI, Philippines, January, 2000.

3.3.1 Impacts of technology development on women

A comparative analysis of the two approaches shows that the technology development path chosen can have very diverse impacts for two projects with analogous goals. Several conclusions can be drawn from this analysis:

(a) Commercializing a "woman's" crop did not necessarily result in benefits for women.
(b) Investing in analyses to understand how technological change affects the intra-household distribution, access and control of household resources would have been useful in evaluating the distribution of technological benefits in order to plan the process equitably.
(c) Basing technology development on an analysis of women's constraints and needs and involving women in all aspects of technology development were important strategies to integrate all consideration in the innovation process, thereby ensuring that women would participate and benefit.
(d) It was important to develop technologies to reduce women's drudgery; however, coupling labor-saving technology with alternative employment opportunities to increase women's labor productivity was the key to ensuring that mechanical technology did not displace women's labor.
(e) Integrating strategies to ensure that women had access to the technology by providing technical training and credit specifically targeted to women was critical in the technology development process.
(f) Building in aspects to increase women's independent income, the control over the technology, and organizing women into groups to increase their bargaining power, are important strategies to ensure that women retain the benefits of technical change.

3.4 WID PROJECT COMPONENTS APPROACH: ADAPTING POSTHARVEST TECHNOLOGY FOR WOMEN

The women's decade spearheaded an intense interest in developing technologies for women. These efforts focused on rural women and their need for agricultural technology, mainly appropriate technology to increase the productivity of rural food processing and labor-saving technologies to alleviate the drudgery of their work (UN 1985). These endeavors, largely led by NGOs, emphasized technology transfer and development rather than research objectives. A large number of the NGO projects promoted tools and technologies for tasks principally performed by women in food processing. This discussion on the WID Project Components Approach was developed by reviewing several case studies that have focused on adapting postharvest technology for women (Appendix 4). Case studies were selected for review on the basis of several criteria: Women were both participants and beneficiaries; women's needs, contributions and constraints were considered at a certain point in the project; and the lessons learned from the projects are applicable across a range of situations.

The introduction of a credit component and facilitating the formation of groups/associations were two strategies used frequently by the WID Project to increase women's participation and enable their access the technologies. The examples also illustrate the various ways in which change agents worked with women to facilitate technical change and development. The case studies also show various strategies for incorporating gender into the technology development process across

a diverse range of opportunities, with diverse consequences. Three main strategies were used to address women's constraints and to develop technologies:

Box 4. Adapting Post Harvest Technology

Entry point: increasing women's income generation

- Decreased workload and drudgery
- Labor productivity stayed low
- Minor income gains
- Weak links between – processing technology; raw material production; women's assets.

⇨ *Developing technology specifically targeted for women's responsibilities.* Most of the case studies in the WID Project Components Approach use this strategy. These projects developed laborsaving technologies for women's traditional tasks and food-processing responsibilities and targeted women from the onset of the project. The incorporation of women's indigenous technical knowledge (ITK) in developing appropriate technologies was an integral part of these projects. In many instances women were already involved in technology innovation; thus the role of the external agents was to help them improve the efficiency of the technology, refine it or increase access to it.

⇨ *Introducing a WID component into an existing project.* In this strategy a gender component was incorporated into an already existing project by reorienting it to increase women's participation. The oilseed press project is a good example of this strategy, where a loan-purchase component targeted for women was integrated into an ongoing program, to enable women to purchase equipment and thereby increasing their participation in the project (Johnson-Welch and Whelan 1996).

⇨ *Developing a technology from scratch, specifically for women.* Two case studies—the introduction of soybeans as a legume food crop in West Africa (Gubbels and A.Iddi, undated) and hydroponic vegetable production in Venezuela (Abad et al. 1995) provide good examples of this approach. This differs from Strategy 3 in that the technology was new and offered new opportunities (new crops and markets).

The cases reviewed in the WID Project Components Approach are summarized in Appendix 4. They represent different development agencies involved in the "appropriate-technology-for-women" efforts: The United Nations Development Fund for Women (UNIFEM) aimed to promote the widespread diffusion of technologies that would increase the productivity of women's labor in food production, processing, storage, preparation and marketing. This work is summarized in various documents; Ilkkaracan and Appleton (1995) and Appleton (1993). Several cases are from Creevy's (1996a) book, which is an in-depth analysis of eight micro-enterprise projects undertaken by three agencies [UNIFEM, Intermediate Technology Development Group (ITDG) and Appropriate Technology International (ATI)]. This book compares different projects from the point of view of the women involved. The final case study was selected from a review

conducted by the International Center for Research on Women (ICRW), which provides invaluable insights and lessons in their review of several projects developed by two NGOs: ATI (Johnson-Welch and Whelan 1996) and CARE International (Weiss and Paolisso 1996).

3.4.1 Impact of technology development on women

A key objective of the technologies developed using the WID Project Components approach was to introduce laborsaving technologies to alleviate the drudgery of women's postharvest and food-processing activities (women's traditional responsibilities and tasks) and to enhance income. In general the impact of the postharvest/food-processing technologies are poorly analyzed and documented; therefore anecdotal evidence is used to derive many of the lessons presented in this analysis. Nevertheless, several conclusions on the impact on women can be drawn from how using the WID Project Component approach impacted on women's welfare:

(a) These technologies impacted positively on women's labor burdens, and in most instances substantial savings in time were made.
(b) Combining laborsaving technologies with small business development opportunities such as commercial processing had a positive impact on women's employment opportunities.
(c) The formation of women's groups/associations to facilitate the management of the commercial processing enterprises resulted in women owning and managing small businesses, which empowered them and increased their bargaining position and self-confidence.
(d) Successful projects involved women in all aspects of technology development and focused on all aspects, from production to marketing/utilization.
(e) The income-generation aspects of the business enterprises were not successful in enhancing women's income because many of the projects focused on traditional women's activities, which were generally low return and marginal.
(f) Many projects experienced problems with sustainability because they focused on one aspect—food processing— resulting in frequent constraints with accessing the raw material for processing.
(g) The production of raw materials and processing activities were not linked, resulting in bottlenecks within the system and threatening the sustainability of many of the projects.

3.5 IMPROVING ASSETS: INM TECHNOLOGY DEVELOPMENT APPROACH

There is evidence that women make a substantial contribution to soil fertility management because of their role in food production in Africa, Asia and Latin America. In sub-Saharan Africa women produce up to 70-80% of the domestic food supply, and they also provide, on average, 46% of the agricultural labor (Gladwin et al. 1997). Because of their critical role in food production, women should be at the core of any strategies to increase farm productivity and to ameliorate soil fertility. Gladwin et al. (1997) maintain that increasing agriculture productivity will require a concerted effort to increase women's capacity to rehabilitate degraded soils. This is especially important because declining per capita food production on small farms is based on soil fertility depletion (Sanchez et al. 1997). In addition, in many parts of Africa, war, sickness and death from HIV/AIDS, coupled with increasing trends in rural male out-migration in search of off-farm income-earning opportunities, have resulted in women taking on the bulk of men's roles and activities in farming (IFAD 1994, FAO 1999).

Although women participate actively in soil management, their expertise and knowledge have been ignored by conventional approaches to soils issues in Africa. Empirical research on the role of women in managing soil fertility is sparse. Few studies have endeavored to integrate gender considerations in technology development in INM/soil fertility management. Most scientists contacted for information on "Gender and Soil Fertility Management" recognized that few studies have endeavored to highlight women's contributions to INM. Others questioned the relevance of focusing our work on women and INM: "*Isn't soil fertility management men's work?*"

The argument that the role of gender has been ignored in INM despite women's critical role in food production is not unique to Africa. In Asian women's contribution to agriculture parallels or in certain areas exceeds that of men, a disparity that is likely to increase as the rate of male out-migration continues to grow (Asia Pacific Regional NGO Symposium 1999). The findings of this regional symposium argue that despite their contribution, women in this region are excluded from environmental decision-making at all levels and in all areas including soil conservation, soil erosion, community forestry, waste and garbage management.

In both Africa and Asia, new INM technologies have failed to harness women's knowledge on environmental management based on their experience and practices; and barriers to women's access to and control of natural resources continue. Thus a necessary condition for improving small farms is to increase the labor productivity of women; and technology development must build on their extensive knowledge in managing soils. To derive lessons on the Improving Assets: INM Technology Development approach this paper examines case studies that analyze why women have not adopted soil fertility-improvement technologies. This is an ex-ante analysis, which applies the lessons from the other case studies to demonstrate the negative effects of ignoring gender considerations.

Box 5. Asset Building through INM

Entry point: women's needs and constraints

- Workload and drudgery decreased
- Labor productivity increased
- Ensured control over key assets
- Impact on independent income not documented.

3.6 ROLE OF WOMEN IN INM

In an in-depth analysis of women's role in soil management, "walking where men walk," Verma (1999) examined the gendered politics of land, labor and soils in Western Kenya. Data were collected using individual interviews, personal narratives, photo appraisals, group interviews and surveys of 46 women (Verma 1999). Her findings established that as farmers and sustainers of the soil, women not only play a critical role in managing the soils, but also possess extensive knowledge and expertise for this purpose. In addition she found that although Maragoli women make the bulk of decisions on soil fertility management, based on in-depth knowledge regarding the microenvironments of their farms, they do not always publicly admit this; therefore agricultural researchers may underestimate their central role. Appendix 5 provides an inventory

of diverse soil management activities that Maragoli women are engaged in. These results demonstrate that women are engaged in diverse soil-management practices, ranging from the use of various organic or inorganic fertilizers (depending on the crops), combinations of organic and inorganic mulching to crop rotation. The Maragoli women's role in managing soils is influenced by several factors:

- ➢ Their access and control over resources within different on-farm labor enterprises
- ➢ Gender, class, age, marital status and household headship, women's priorities, traditional norms and the crops grown
- ➢ The amount of time and labor invested in other off-farm livelihood strategies, and as their labor burden extends, women may be forced to engage in unsustainable soil-management practices because they are constrained from adopting soil-management practices that require labor-intensive inputs.
- ➢ Lower incentives to engage in labor-intensive soil-management practices in activities over which they have no control over the proceeds of their labor. In these instances women prefer to focus their time and labor on certain microniches on their farms where they have long-term security of tenure and where they control the products of their labor.

These findings corroborated several earlier studies. For example, Puhalla (1997) found that women in Uganda play an important role in managing soil fertility by applying manure and crop residue, and fallowing their fields. Women played a significant role in managing soil fertility, and about two-thirds of the women surveyed applied manure to their fields. A majority of the women also spread out crop residue over their fields and later plow it under during land preparation. Puhalla (1997) also reports that the women in this region leave their fields fallow as a strategy to rebuild soil fertility. In comparable work conducted with men and women farmers in Mbale district, Goldman and Heldenbrand (1999) found that there were slightly more women (married) than men who used manure to improve soil fertility. On the other hand, a lower percentage of single women (than the men) used manure, reflecting their limited access to livestock. Other strategies used by an equal number of men and women were composting, use of household refuse, mulching and agroforestry.

In addition to their contribution to soil-fertility management, women also have a wealth of indigenous knowledge on the symptoms of nutrient deficiencies caused by low soil fertility. Field validation studies to establish nutrient-deficiency symptoms in sweet potatoes demonstrated that men tended to give more general descriptions, while women gave a more detailed assessment of symptoms (Tulin et al. 1999). These findings are supported by work at Maseno, where women provided more detailed knowledge on the soil-fertility assessments within their plots, while men had more knowledge on larger scale dimensions such as the boundaries of their farms (Mwendwa pers. comm. 1999).

3.6.1 Impacts of technology development on women.

Several conclusions can be drawn from this analysis:

(a) Women are important managers of the soil, but they are constrained from accessing and adopting improved soil-management technologies because technology development processes do not take into account their constraints and needs.
(b) Technology development approaches in INM may repeat the errors of technology transfer

approaches of the 60s and 70s, where women's constraints and needs were not taken into consideration; i.e. labor constraints, intra-household resource allocation and incentives to invest in new technology.

(c) Trends in rural-to-urban migration and the proliferation of male off-farm employment have resulted in women taking on more on-farm and soil management responsibilities that were traditionally the men's domain. These new responsibilities, coupled with women's other roles, may undermine their ability to sustain the soils.

4 SYNTHESIS: IMPLICATIONS FOR FUTURE WORK

Analyses of the cases have been synthesized in order to derive conclusions about different approaches for improving the benefits to women from improved technology. The questions of what worked, what did not and why are central to this analysis. A comparison of the four approaches adopted (summarized in Table 2) shows that there are five key factors in successful efforts to benefit poor rural women with technology innovation:

(a) use of a "resource-to-consumption system," which links the management of natural resources and production aspects to the marketing and consumption of crops and products
(b) inclusion of a research component as well as technology transfer component
(c) a labor productivity-enhancing, drudgery-relief strategy for introducing new technology
(d) taking into account the differential constraints in access to and control of resources between men and women, and consideration of intra-household dynamics in project design and technology development
(e) strengthening social capital and organization to enable women to maintain control and improve their bargaining power and building in strategies to ensure sustainability of the project -- that is, women retain control of the technology after it becomes profitable.

In this section of the paper we are concerned with an analysis of what worked and the reasons why some approaches successfully designed technical change that benefited women. The discussion is organized around each of these issues that have emerged as critical to the development of technologies that benefit women: labor productivity; access to and control over production resources; intra-household dynamics and their implications; research versus technology transfer; and social capital and organization. The final section pools the analyses and develops a resource-to-consumption system, which ties all the different aspects together.

Table 2. Comparison of approaches: Experience in agricultural research targeting women as the beneficiaries.

Approach (headings refer to features of each approach)	Commodity Research with Technology Transfer	Systems Research Targeting Women	WID Project Components: Women's Traditional Roles	Improving Assets: Integrated Nutrient Management	"Resource-to-Consumption" Approach
1. Intra-household dynamics & their implications for technology development	↓ No baseline analysis to understand intra-household control, access & resource allocation. Project outcomes: • Women lost rights to swamp land and therefore control over their independent crop.	↑Scientists conducted initial diagnoses with women & men farmers, thereby developing an understanding of intra-household resources allocation & constraints and their implications for technology development	↓ Majority of projects did not invest in serious diagnoses.	↓ Technology development has not analyzed the highly complex processes that affect women's access to and control of resources, such as labor, land & capital - Women are constrained from adopting high labor- & capital-intensive technologies.	Conduct a comprehensive beneficiary analysis using participatory approaches including gender analysis & secondary data. • To consider women's needs & constraints, assets and their incentives for undertaking new activities. • To understand intra-household resource allocation & gender differences in access to production resources.
2. Incorporating a research & technology transfer process	Technology transfer process; no adaptive research to integrate farmer circumstances	Examined the entire production-to-consumption system to understand bottlenecks & opportunities.	Technology transfer - Disjunction between processing technology & research on raw material production.	Research focused on resources/ components without addressing linkages between production & processing.	It is crucial to develop technology by addressing the entire commodity chain from sustainable resource management, production, processing to marketing & consumption.

3. Impact on women's labor burdens (Did technology reduce drudgery?)	↓ Technology increased demands on women's labor because men were able to draw on women's uncompensated labor obligation to cultivate household (*maruo*) land.	↑ Reduced drudgery by introducing mechanical technology for seeding, dehulling, threshing, milling, etc.	↑ Introduction of food-processing equipment reduced drudgery by replacing labor-intensive traditional methods with improved mechanical technology.	↓ Soil-fertility technologies accessible to women (organic methods) have high labor requirements.	***Productivity-enhancing, drudgery-relief* strategies** Labor-saving technology should be partnered with productivity-enhancing technology, involving: • Development of labor-saving technologies in areas of low returns • Strategies to increase women's labor productivity, focusing on new productivity-enhancing opportunities, such as nontraditional crops & products
4. Labor productivity (Does technology increase output and lead to intensification in agriculture?)	↓ Women's labor productivity in individual farming decreased (70% less than men's) because of their reduced access to inputs, laborsaving technologies, increased labor burdens.	↑ Increased women's labor productivity by introducing early-maturing, high-yielding rice varieties, & new income-generating opportunities (small livestock).	↓No substantial increases in labor productivity because technologies focused on women's domestic/ traditional activities with low economic returns.	↓ Women are constrained from adopting technologies that increase labor requirements because they have differential access to inputs, land, capital, credit, technical training & extension services.	
5. Impact on women's access to and control of resources (land, labor, capital)	↓ Commercialization of commodity diminished women's access to productive resources; they lost their rights to swamp land and therefore control over their individual crop, which became a communal crop under control of the male head of compound.	↑ Improved production of women's enterprises (small livestock), which provide independent sources of income & security for women. Access to credit was built into project.	↓ Although projects had a credit component built in, success was limited for lack of access to working capital & raw material for processing.	↓↑ If technology development does not address women's access to and control of resources (land, labor, capital), then it may impact women negatively.	By understanding women's access to and control of resources, technological innovations can be compatible with women's constraints in managing both the natural resource base & the production system.

6. Impact on welfare (income & empowerment)	↓ Women had less income because of their loss of independent sources of income (traditional rice cultivation), thereby reducing their intra-household bargaining power.	↓↑Impact not well documented. Anecdotal evidence shows women were empowered by managing the business as a group, leading to skills building, entrepreneurial experience, machine operation, leadership & higher income	↓↑Women made marginal profits as projects were not financially viable; however, formation of groups empowered women to work together to increase their bargaining power.	Technologies should address distribution of technology benefits.	Technologies that benefit poor rural women must: • Link increased returns to women's labor & their independent income • Build a strong association between agricultural intensification and women's capacity to rehabilitate the natural resource base on which this intensification depends. • Incorporate rigorous impact assessment to increase learning from experience & project benefits.
7. New opportunities (Does technology offer alternative options to increase income?)	Project did not address new opportunities to diversify income sources.	↓↑ Project focused on intensifying production of women's crops & livestock, and introduced new opportunity for them in an existing market.	↓ In majority of the cases, technologies focused on women's domestic & traditional activities with low economic returns and scant opportunities for improving their socioeconomic status.	↓↑The strong association between agricultural intensification & investment in improved INM and poverty alleviation justify increasing women's capacity to rehabilitate degraded soils.	New opportunities for technical innovation should focus on integrating nontraditional crops & products into the farming systems.

Sustainability (Did women retain control of the technology after it became profitable?)	↓ The introduction of new technology in rice production—a woman's crop—resulted in the crop's becoming male controlled.	↑ In most instances when women's traditional roles becomes mechanized, men take over. This did not happen in this case because women proved they could manage the mill.	↑ In many instances women were able to retain control of their projects.	↓↑ The technology-development process has to develop mechanisms to ensure that women retain control after commercialization occurs.	Several things will promote sustainability of the projects: • Targeting the technology to women • Involving women in all phases of the technology-development process • Building on women's traditional knowledge to ensure that women can retain ownership of the project after it becomes profitable
8. Social capital & organization	By forming work groups for hire, the Mandika women in Gambia, were able to counter household-head pressures to work year round without adequate remuneration and to renegotiate for higher wages.	Introduction of the micro rice mill facilitated the formation of an association, which empowered women and improved their capability to manage the mill. • Giving women control of income generated from operating the mill • Men did not take • over the project because women could manage the mill by themselves.	Almost all projects facilitated the formation of groups, which resulted in: • Facilitating ownership of technology , making it easier to own and manage the commercial enterprises as groups • Sharing risks among the group members.	Building social capital through organizing women into groups is an important strategy to empower women.	Organizing women into groups for collective relationships because members of associations are more likely to exercise greater bargaining power both within the household & the community. • Forming cooperatives/ associations not only facilitates ownership of technologies but also helps spread project risks among group Members. • Incorporating continuous monitoring & evaluation increases learning from experience.

4.1 LABOR PRODUCTIVITY

An important conclusion of this analysis is that technical change intended to benefit women must first address the issue of labor, which consists of three aspects:

- ⇨ Developing laborsaving technologies to alleviate women's drudgery and labor burdens in low-return areas; otherwise the women will not have the time to allocate to technologies that improve welfare.
- ⇨ Improving returns to women's labor is critical to increasing their labor productivity. Traditionally, most labor productivity-enhancing technologies have focused on improving women's productivity in their traditional roles and responsibilities of food processing.
- ⇨ Strategies to increase women's labor productivity should focus on new productivity-enhancing opportunities such as nontraditional crops and products. Therefore, strategies to improve the productivity of women's labor, while addressing the constraints that result from drudgery, are crucial to ensuring women can benefit from technical change. We have called this a "*productivity-enhancing, drudgery-relief strategy*."

An effective productivity-enhancing drudgery-relief strategy will develop labor-saving technologies in areas of low returns—notably, women's roles and responsibilities in the production and processing of major staples (maize, rice), especially where they do not control the products—to free women's labor for activities with higher returns. Nevertheless drudgery relief in itself is not enough, even if it frees up time for other pressing traditional activities, because in some instances it may displace women's labor. It is well known that when mechanization has displaced female labor without alternative employment, women are worse off (Begum 1985). To counter these displacement effect, almost all WID Project Components reviewed here, introduced drudgery-relief technologies in conjunction with alternative employment and income-generating opportunities such as the formation of groups to own and commercially operate the technology (UNIFEM 1995; Creevy 1996e)

The WID Project Components incorporated an income-generating component in all their projects, with the aim of increasing labor productivity. Our findings show that the introduction of improved mechanical technology for food processing reduced drudgery by replacing traditional labor- intensive methods. However, increases in labor productivity were not significant because the technologies focused on women's domestic/traditional activities, which yield marginal or low economic returns. Technologies that reduce women's workload and drudgery must be accompanied by complementary technologies to offer **new** productivity-enhancing opportunities that enable women to increase their independent income and bargaining power over their time and labor. A WID Project Component case (i.e. the vegetable production project in Venezuela using hydroponic technology) provides a good example of increasing labor productivity through the introduction of nontraditional vegetable production and marketing (Abad et al. 1995). This project was successful in increasing labor productivity because the technology development process focused on:

(a) linking production aspects to marketing, thereby coordinating interventions to increase labor productivity in the entire system—production to marketing.

(b) involving women in the entire technology development process, including training women on how to analyze and take advantage of new market opportunities
(c) integrating nontraditional crops and products into female production processes

The project also included aspects to reduce production costs, improve quality based on market demands, and new product development. Another example of an effective productivity-enhancing, drudgery-relief strategy is found in the Systems Research Targeting Women approach, used by WIRFs. By recognizing the linkages among women's various roles of production and processing, WIRFS introduced complementary technologies to reduce women's drudgery in food processing through mechanical technology for seeding, dehulling, threshing and milling; and increased women's labor productivity by introducing early-maturing, high-yielding rice varieties and other new income-generating opportunities such as small livestock and sericulture.

In conclusion, the benefits of drudgery-reducing technologies depend on how the time released is utilized. Increasing labor productivity requires the development of technologies that not only increase returns to women's labor but also their independent income; and they need to look beyond women's traditional roles to new opportunities such as nontraditional crops and products.

Box 6. New opportunities for research to benefit women

New entry point: alternatives that increase returns to women's labor and their independent income

- Technologies for intensifying agriculture must also increase women's labor productivity.

4.2 ACCESS TO AND CONTROL OVER PRODUCTION RESOURCES

The foregoing analysis of what has worked (or not) and why in different approaches to benefit women from technological change identified the development of women's productivity-enhancing, drudgery-relief strategies as critical to ensuring that women benefit from technical change. The second factor that emerges from this analysis is taking account of women's constraints in the access to and control of agricultural resources and building process mechanisms into the technology development to address these concerns.

Women have unequal access to and control over land and associated resources (water, woody plants, fishery resources, etc.) and their impact on their welfare. Various approaches have been proposed to classify bundles of rights such as access, withdrawal, management, exclusion, and alienation (Schlager and Ostrom 1992), we are usually concerned with use rights, which permit access and withdrawal of the resource. The question of access and control to land is raised often in poverty debates because land is the most important productive input. Land rights are often women's entry point for accessing other productive services: credit, irrigation water and often produce from trees (Meinzein-Dick et al., 1997; FAO 1999a). There is also a close association between access to land and to capital because the former is often used as collateral in accessing

the latter. Therefore the lack or perceived lack of secure tenure to land can reduce women's motivation to invest sustainable soil- and nutrient-management strategies.

In many instances women face severe constraints that can affect their ability to adopt many soil-improvement technologies:

- ➢ lack of access to and control over land, capital and credit markets, and therefore, inputs
- ➢ women have a heavy labor burden and lack access to labor
- ➢ women lack access to technical information

Gladwin et al (1997) found that women did not adopt technologies that required the application of inorganic fertilizers because of their lack of cash, capital or credit. Empirical research conducted in Malawi and Cameroon showed that gender differences in wealth contributed substantially to strategies to the use and nonuse of fertilizer (Gladwin 1992, cited in Gladwin et al. 1997).

Nevertheless, there are examples in literature where poor women will invest in improved resource-management technologies without holding the full bundle of rights. For example, women will invest in resources if they are assured that they have use rights; that is rights to enter a defined physical property and to obtain the benefits from that property by taking out some of the flow. Verma (1999) found that Maragoli women invested their time and labor on certain microniches on their farms where they could control the products of their labor; whereas they had fewer incentives to engage in labor-intensive soil-management practices, activities over which they had no control of the proceeds of their labor.

Technology development needs to invest in extensive baseline surveys to understand the differential access to and control of resources within the household in order to consider these limitations and build in safeguards to protect and enhance women's assets and spheres of control. By failing to take these aspects into account, the Commodity Technology Transfer approach marginalized women further. The commoditization of rice in Gambia resulted in the appropriation of women's traditional swamp land, women lost their rights to personal land and thus their control over income from selling surplus rice produced on these plots (Dey 1982; Carney 1992). On the other hand, by considering women's constraints in accessing land, a WID Project Component case—CARE/Guatemala's WID initiative—recommended activities that did not require high inputs of land such as raising small livestock (Weiss and Paolisso 1996). In addition a majority of the WID Project Component cases incorporated a credit component in their projects to increase women's participation in the projects.

In conclusion, it is important for the technology development process to take into account women's lack of access to land and resources to intensify agriculture (i.e. cash, fertilizer or manure) and to design technologies where these limitations are taken into consideration. This may be achieved by developing technologies that increase women's access to these resources, building their assets; technologies that do not have high capital, land or labor requirements; or by developing policy options to give women property rights. This last option is perhaps the most

challenging of all, but providing women with equitable rights to land is crucial because they form an increasingly important segment of the local and national economic and social capital.

4.3 INTRA-HOUSEHOLD DYNAMICS AND THEIR IMPLICATIONS FOR TECHNOLOGY DEVELOPMENT

In our analysis of what has worked (or not) and why in different approaches to benefit women from technical change, we have identified three critical factors:

- ➢ Development of technologies with a productivity-enhancing, drudgery-relief strategy
- ➢ The need to take into account women's constraints in the access to and control of agricultural resources
- ➢ Consideration of intra-household resource allocation

The analysis of what has worked and why with technical innovation shows how efforts intended to benefit women can get derailed if they neglect the often complex intra-household dynamics in resource allocation and decision-making (von Braun and Webb 1989; Aldermann et al. 1995; Doss 1998). Recent empirical evidence demonstrates that the assumption that households behave as a single entity with the same preferences is not appropriate in a variety of settings in both developed and developing countries (Doss 1998). A new class of collective models—Noncooperative and Cooperative bargaining models—recognize that households are sites of conflicts as well as cooperation and help to explain how resources are allocated differentially among household members.

These bargaining models use the game-theory approach to incorporate a more complex understanding of how family decision-making occurs and allow for individual differences in preferences, budget constraints and control over resource use (Agrawal 1997). The Cooperative model proposed by McElroy and Horney (1981) and Manser and Brown (1981) assumes that households reach a Pareto efficient outcome (Doss 1996); that is, that households pool their income and labor and then bargain over how to allocate them; and that household decisions are reached via a cooperative Nash game. Analogous to this model, the Noncooperative approaches (Ulph 1988; Kanbur 1991; Carter and Katz 1992) assume that household income is not pooled. These models allow for individual preferences and decisions as to their consumption and production based on their own labor and access to resources. One implication of these collective models is that household decisions often reflect the bargaining power of its different members; e.g., when women have control over resources, they will use them differently than men do, often spending more on children, with differing results for household welfare. The collective household model also suggests that the identity of the individual targeted by a technical change (man, woman or child) will affect how resources are used and who benefits; thus interventions that ignore the identity of the recipient and simply target the household as a whole may not be successful.

How do we apply these concepts from collective household models to interpret our findings on the impacts of technical change in the analysis? Our analysis shows that a *beneficiary diagnosis*[3]

[3] A beneficiary diagnosis is an extensive baseline survey using participatory approaches.

is crucial as a starting point to flesh out intra-household allocation and control over resources and responsibilities in order to understand constraints and then trace these constraints forward/backward along the resource-to-consumption system. That technology design and testing need to be done in the context of intra-household relations. Therefore, the assumption that households behave as a unit—i.e. that men are the best judge of what is beneficial to women or that a priori they are likely to achieve a Pareto-efficient distribution of goods within their household—are incorrect.

In the cases reviewed the Commodity Technology Transfer example women were marginalized as a result of treating the household as a unit, by naming irrigated rice plots "household plots" (*maruo*) and extending new technology to the male head of household. Women lost their rights to swamp land and control over their independent crop, and rice went from being a woman's individual crop to a communal crop under the control of the male head of compound. Likewise, the introduction of an irrigated rice project to increase the intensity of rice cropping in the Cote d'Ivoire faced similar challenges (Dey 1982). In this region women planted rice in the lowland areas (*dambos*), and men were dedicated to growing rain-fed maize, yams and rice. The introduction of new technology did not lead to increased rice production because women were unwilling to contribute their labor to an enterprise with no additional returns for them.

In contrast the Systems Research Targeting Women approach not only took into account that household income is not necessarily pooled, but also recognized the importance of women's control over their own resources. This was done in two ways:

- ⇨ WIRFS scientists conducted a beneficiary diagnosis to orient applied and adaptive research, using participatory approaches, gender analysis and secondary data to analyze carefully and take into account women's constraints (time, capital, etc), existing income sources and assets over which they have control (e.g. small livestock), and their incentives for undertaking new activities. As a result, WIRFS defined a research agenda that not only incorporated women's priorities but also did so in relation to intra-household dynamics.
- ⇨ WIRFS the technology development process branched outside commodity research to include other features of the farming system (e.g. small livestock such as swine and poultry), the benefits of which accrued specifically to women and increased their independent income and assets. This flexible approach was different from that taken in by the Commodity Technology Transfer approach, where a set objective was pursued implacably from the start; e.g. installing large-scale pump.

Two other projects from the WID Project Components food-processing cases took intra-household dynamics into account from the beginning. A project to promote soybean production in Togo, Ghana and Mali and a hydroponic vegetable production project in Venezuela both succeeded because the collective nature of household behavior was built into the technology design (Dankelman and Davidson 1986 cited in Alderman et al. 1995; Abad et al. 1995; Ikkaracan and Appleton. 1995). Both projects specifically targeted enterprises amenable to control by women, who were involved in all aspects of the project—from needs assessment to technology dissemination. Soybeans were introduced as a new food crop to be used in sauces traditionally produced by women, rather than as a cash crop. The technology development

process used a participatory research process to integrate women in all aspects of the crop, from production to utilization. Thus soybeans, unlike the Commodity Technology Transfer examples in rice systems, remained under the women's control; and in some instances the women's husbands allocated small plots for them to cultivate (Dankelman and Davidson 1986, cited in Alderman et al. 1995). The vegetable production project followed a similar path: the technology specifically targeted women, took into account the women's needs and constraints, and the technology development process involved women in the entire production-to-marketing process. In both cases the projects organized training workshops so that the women could increase their access to the technical skills needed for both production and utilization, the technology development process incorporated all aspects of the production-to-consumption chain, and ensured that women were able to control all aspects of product development.

Analysis of the Improving Assets, INM Technology development approach demonstrates that women are constrained in adopting technologies that fail to consider or understand the highly complex process that affects their access to and control of resources, such as labor, land and capital. For instance, Kumwenda et al (1996) found that women were unable to adopt a technology to increase nitrogen fixation because it recommended that beans should be planted as a sole crop. The introduction of agroforestry technologies faced similar challenges to those highlighted above. In her study in Maseno, Kenya, Williams (1997) interviewed 40 women farmers to elicit their reasons for adopting or not hedgerow intercropping technologies. Her findings indicated that the commonest reasons for nonadoption were the shortage of land and labor constraints, especially in regions where agricultural intensity and population density were high. Adoption was also constrained by the high labor requirements for topping the trees. Williams (1997) decision-tree model predicted that only 8 out of 40 women would adopt hedgerow-intercropping technologies.

Our analysis indicates that unless technology development takes into account the highly complex processes that affect women's access to and control of resources, their constraints, existing income sources and assets, technology development will leave women worse off.

4.4 IMPACT OF THE TECHNOLOGY DEVELOPMENT PROCESS: RESEARCH COMPONENT VS TECHNOLOGY TRANSFER

Up to this point the analysis of what has worked and why (or why not) in different approaches to benefit women from technological change has identified three important factors: strategies to improve the productivity of women’s labor while addressing the constraints that result from drudgery are crucial to ensuring women can benefit from technical change; successful approaches must take account of women's constraints in the access to and control of agricultural resources; and specific consideration of intrahousehold dynamics in project design and technology development. Continuing the analysis of what has worked and why in this analysis of experiences with technical innovation intended to benefit poor rural women, a fourth important finding is that for women to benefit from technical change it was crucial to include a research component in the innovation process. This was typically research to solve bottlenecks somewhere in the commodity chain from production, processing to marketing and distribution.

In the Systems Research Targeting Women (WIRFS example), technology development in glutinous rice provides a good example of the importance of a research component developed by focusing on the entire commodity chain. In this case a limited supply of glutinous rice [due to low yields and the limited area devoted to its cultivation] resulted in a constraint on the supply of raw material for the women processors. In addition, the processing of glutinous rice was a laborious, time-consuming process (Paris 2000). By introducing a research component and working with both men and women farmers, WIRFS was able to develop an early- maturing, higher yielding glutinous variety with taste and eating qualities comparable to the local varieties. At the same time, the development of complementary dehulling equipment to improve efficiency and reduce the workload and drudgery in hand-pounding, resulted in an overall increase in labor productivity (value-added gross returns, 70%). By building a research component into this process, WIRFS achieved two goals: high-yielding glutinous rice varieties addressed the yield bottlenecks in raw materials for processing. Secondly, by using a participatory research process to develop dehulling technology with women, engineers took women's constraints and perspectives into account in the design, thereby developing an appropriate technology to address the women's constraint with respect to hand-pounding.

In contrast, by focusing on technology transfer in isolation from research, the WID Project Components approaches encountered bottlenecks in raw material supply because there was a disjunction between the transfer of processing technology and research needed on raw material production. As a result, the processing technologies of several projects were unsustainable because of production bottlenecks not addressed by research. For example, the oilseed press technology to extract oil from sunflower seeds encountered numerous challenges related to production, such as yields, oil content, agronomic constraints and milling quality, which could have been dealt with through a research process on production-related aspects (Johnson-Welch and Whelan 1996). Similarly, in West Africa remarkable increases in productivity brought about by the introduction of improved mechanical cassava processing technology have been unsustainable because of insufficient supplies of raw materials, which could also have been resolved by including a research component (Carr 1997).

4.5 SOCIAL CAPITAL AND ORGANIZATION

The analysis of what has worked (or not) and why in different approaches to benefit women from technological change has identified several important factor:

- ⇨ Improving women's labor productivity using *productivity-enhancing, drudgery-relief* strategies, taking into account women's constraints in the access to and control of agricultural resources
- ⇨ Investing in baseline surveys and analyses to understand intra-household dynamics in technology design and development
- ⇨ Including a research component in the technology-innovation process
- ⇨ Forming and working with women's groups

Group membership empowered women to manage and retain control small business enterprises. The majority of the WID Project Component cases facilitated the formation of groups. In one case the project helped women form a group, "Association for Progress" to buy a diesel-operated

palm kernel cracker for commercial processing of the kernels (UNIFEM 1995). In a similar example, the Systems Research Targeting Women (WIRFS) approach facilitated the formation of a women's group to run a micro rice mill as a commercial venture (Paris 2000). By working in groups, women were able to spread costs of purchasing bulky technologies; e.g. women's groups in Tanzania and Zimbabwe were able to access credit to purchase and manage oil presses (Johnson-Welch and Whelan 1996). The formation of cooperatives/associations, besides facilitating the ownership of mechanized technologies, also helped spread project risks among group members.

The greatest benefit of group membership is that it increases women's self-confidence and their bargaining power, both in the community and in the household (Kabeer 1995). Anecdotal evidence from different cases across the approaches indicates that the ability to organize themselves into work groups/associations played an important role in improving women's bargaining power and ability to control their lives and increase their remuneration (Carney 1992; Paris 2000).

4.6 BUILDING ASSETS AND LINKING INTERVENTIONS: THE RESOURCE-TO-CONSUMPTION APPROACH

In our analyses of what has worked (or not) in different approaches to benefit women from technological change and why, we find that technical change intended to increase rural women's labor productivity and welfare must be designed and tested in a resource-to-consumption system.

Technological innovations must be compatible with women’s constraints in managing both the natural resource base and the production system because their adoption of new resource management and production technologies will be heavily dependent upon the productivity of women’s labor and on their control over assets in both domains. Pre- and post-harvest activities (including agro-processing, marketing and consumption) need to be considered together because women are allocating their time and other resources across the full continuum production to consumption. This argument is supported by Reardon (2000), who argues that research should emphasize pre- and post-harvest together, including agro-processing activities, because the threats, opportunities, and challenges to rural farmers need to be seen in the “*meso agrifood system” context, from “farmer to dinner plate*.” Figure 2 illustrates these linkages, together with the criteria for defining “appropriate” technology for women.

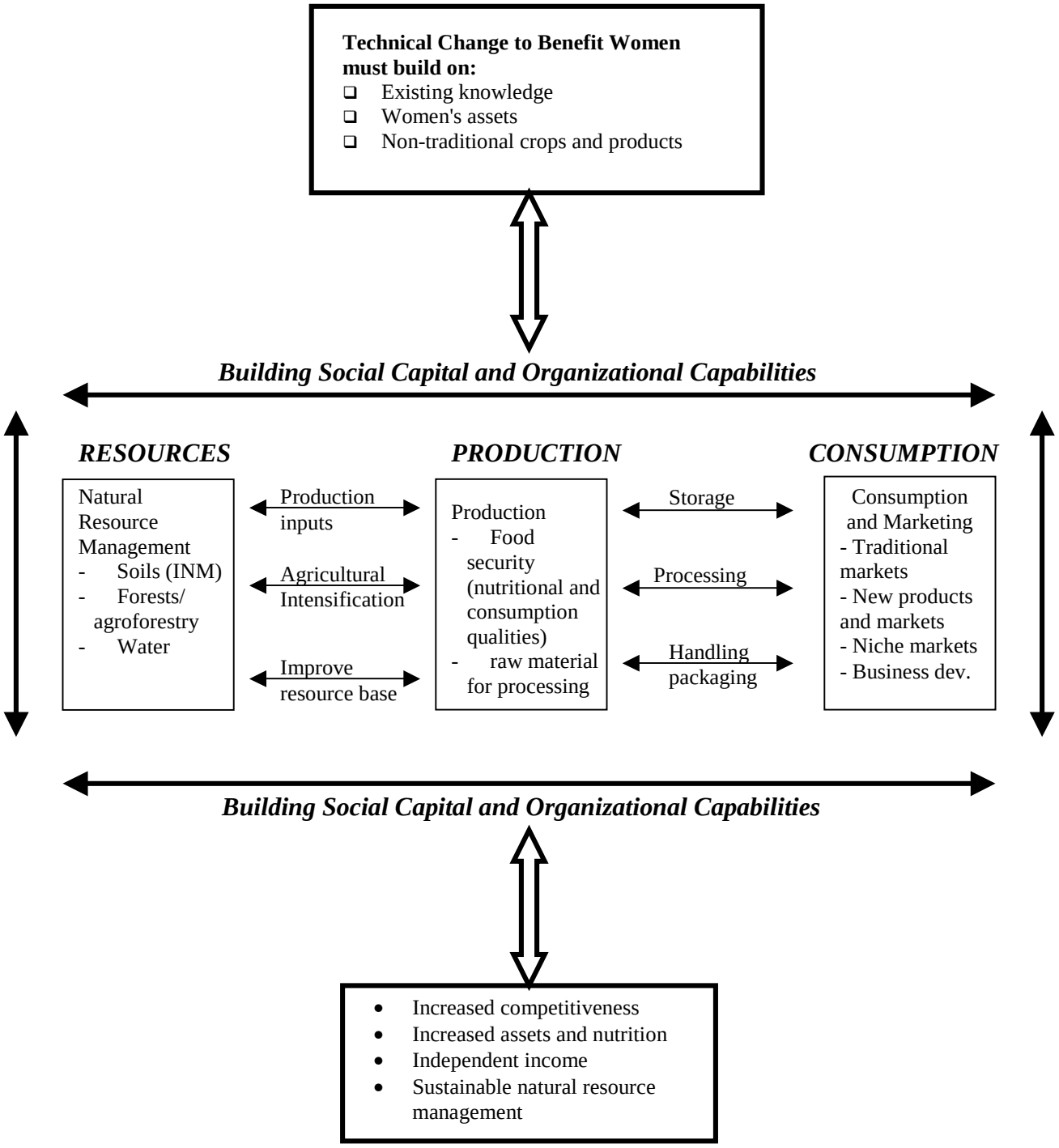

Figure 2. "*Resource-to-consumption*" approach.

Our findings show that, the criteria for defining appropriate technology for women need to shift away from traditional areas of responsibility and towards areas with increasing returns to women's labor. Whether in traditional or nontraditional activities, this requires focusing on making women's on-farm production and postharvest activities more competitive. New resource management, production and postharvest technologies must address relief from drudgery and increase returns to labor in an interconnected way. In order to take advantage of opportunities with higher return for their labor, women farmers need time released from drudgery. Correspondingly, the returns on technology providing relief from drudgery are only fully realized if a more productive alternative is available for women's time. Another important criterion is the extent to which rural women's independent income is likely to be affected by technical innovations in resource management, farm production or postharvest processing. This needs to be a key indicator for ex-ante evaluations of technology. Independent income can be correlated with women's bargaining power within the household, as well as the land or capital assets and labor under women's control.

Developing technology that benefits women within a resource-to-consumption system does not mean working on all aspects of the system at once. The experiences reviewed in this paper show that in contrast to starting with constraints to production of a commodity or to improving soil fertility, a research process that begins with the constraints of the beneficiary group increases the probability that these constraints will be factored into the technology development process, given the prior objective of improving that beneficiary group's welfare. The problem or opportunity where technology innovation can most benefit rural women needs to be identified with a beneficiary diagnosis [i.e. one that starts with an analysis of women's constraints and resources]. If, for example, the relevant entry point for new technology is in the resource management domain, the implications of a technical innovation for women need to be traced forward/backward through the resource-to-consumption system. Because the linkages related to women's constraints in a resource-to-consumption system are often complex and little understood, there is a strong case for using participatory diagnosis in combination with other methods. The summary of a CARE project in Guatemala shows how using a resource-to-consumption approach can increase project benefits for women by starting with an analysis of their needs and constraints, and then developing a flexible program approach that links natural resource management with production and consumption aspects (Box 7).

It is important to point out that women are not a homogeneous interest group, and some women producers face fewer constraints and have more in common with men producers than they do with other women. The definition of who is in the beneficiary group(s) is therefore an important step in the research process to develop technology *for* a specified group. The linkages within a resource-to-consumption approach can be characterized as follows:

(a) *Resource management-production linkages in a resource-to-consumption system*. There is strong justification for linking technological innovation in resource management to consumption/marketing processes. The association between increasing labor productivity through intensification in agriculture and increased incentives to invest in improved and sustainable natural resource management is mutually reinforcing. Improved agricultural productivity increases the incentives to invest in sustaining the resource base, and vice versa. Analogously, by focusing on the linkages between the management of resources and production systems, it is easier to build in strategies to protect and conserve resources early on in the production process.

(b) *Production-postharvest linkages in resource-to-consumption systems*. Similarly, it is also crucial to link production decisions to marketing and consumption patterns. Belcher (1997) argues that linking the production of raw materials to the marketing aspects is important because, marketing is a major component of product development. The reverse is also true: focusing on the marketing aspects alone ignores the other important group of participants in this process, the producers. It is not productive to separate marketing and non-marketing participants because many important decisions made by farmers involve production planning in relation to market opportunities and constraints (Harrison et al. (1987). By focusing on the entire commodity chain, technical innovation to improve women's agricultural productivity can link the goals of improving small farm competitiveness; increased assets, nutrition and independent income to the sustainable management of the natural resource base. Examining the entire commodity chain presents many opportunities for increasing employment opportunities for women in other parts of the commodity chain and for linking networks of women producers and traders (Carr 1997). In addition, this approach offers the opportunity to link production to consumption qualities or processing qualities such as yield, milling quality or increased oil content (e.g. sunflower processing) and to understand bottlenecks and opportunities in the system.

(c) Resource management-postharvest linkages in resource-to-consumption systems. It is also important to develop the linkages between the management of soil nutrients and processing and consumption requirements. One aspect of this linkage is with product development in "niches" or specialized markets. For example, there are emerging markets for organically grown crops and products. The growth figures are for organic products. The annual growth rate is more than 20% in the EU and the USA, and it is estimated that 15% of the food in the world will be organic in 2005 (Ostertag, CIAT, pers. comm. 2000). This close relationship between how the soil nutrients are managed and the quality of products required by consumers will necessitate closer linkages between these two aspects.

Box 7. Taking into Account Women's Needs and Constraints:
Women in Natural Resource Management
*(**Source:*** Weiss and Paolisso 1996)

A successful project on natural resource management demonstrates the importance of taking into account women's needs and constraints and of working through the aforementioned resource-to-consumption system linkages in technology development. The project's main objective was to alleviate environmental degradation in a village in Guatemala, and a special effort was made to increase the participation of and benefits to women. CARE initially conducted a *beneficiary diagnosis*, including a gender analysis to identify women's constraints, needs, existing income sources and their incentives to undertake new activities. The diagnosis showed that in addition to a lack of land and income, lack of time was also identified as a constraint. To address women's labor constraints, the project offered activities with low labor requirements such as raising small livestock. In addition, the beneficiary diagnostic surveys showed that women were not a homogenous group; therefore there was a need to build flexibility into the program by providing an array of technologies for women to choose from (basket of options). The diagnosis also showed that CARE needed to give special consideration to alternative income opportunities for activities controlled by women, particularly those that yielded short-term benefits, either income or food for home consumption. To address these concerns, CARE made available to women groups vegetable seeds and small plastic bags to plant seedlings. The project also took into account women's constraints with respect to land ownership and provided other technology that did not have high land requirements. In other instances the project helped groups obtain land from donations of private or public land. As a result CARE was able to offer both short-term financial benefits to women's groups (vegetable production) and long-term benefits (soil conservation and agroforestry). The result was greater agricultural productivity, increased independent income and assets, and at the same time, investment by women in sustainable natural resource management.

5 GUIDELINES FOR ENGENDERING TECHNICAL INNOVATION SUCCESSFULLY

The central message from the analyses of the foregoing approaches is that successful integration of gender in technology development requires both scientists and development agents to make *"proactive efforts"* to ensure that women will participate and benefit from technical change. Our analyses demonstrate that if the technology development process does not incorporate specific strategies to increase women's participation, to take into account their needs and constraints, and their incentives to invest in new technology, women may not participate, and thereby will not benefit from the innovation. Our analysis shows that, in instances where R&D has targeted a generic beneficiary group called "smallholders," women either did not benefit equitably or not at all, or experienced negative impacts. This occurs time and again because women face different constraints from men and have different incentives to invest in or adopt new technology. Especially important is the disincentive to invest labor and time in technical innovation when women do not control the products, generate independent income or improve their bargaining power.

The guidelines developed here represent a variety of successful strategies for integrating gender concerns into technology development. Although none of the approaches reviewed here used all of these strategies, the successful cases all integrated the first guideline—conducting a comprehensive baseline survey.

- *Conduct a comprehensive baseline survey using both participatory approaches including gender analysis and secondary data.* This would be a useful tool for analyzing carefully and taking into account women's constraints (time, capital, etc), their existing income sources and assets over which they have control (certain crops and small livestock), as well as their incentives for undertaking new activities. A comprehensive baseline can also be used to understand intra-household resource allocation, especially land and labor, in addition to identifying gender differences in access to resources such as land, labor, capital, information and existing technology.

- *Develop technology by addressing the entire commodity chain from sustainable resource management, production and processing to marketing and consumption.* This is crucial in improving women's welfare because in general women's roles and responsibilities span the entire commodity chain (women are producers, processors and are also involved in marketing activities). Cases that addressed only one aspect of the commodity chain such as access to technology, encountered different constraints only along the production-to-consumption channel. Examining the entire commodity chain presents many opportunities for increasing employment opportunities for women in other parts of the commodity chain and for linking networks of women producers and traders. This analysis demonstrates that by focusing on the entire commodity chain, women developed an understanding of all aspects of the commodity (production to marketing) and were able to retain control and use rights to the technology even after it became profitable (Abad et al. 1995; Paris 2000).

- *Involve women in all phases of the project cycle and incorporate their recommendations in technology development*. The most successful examples where women benefited from technical change were the projects where women were included in all the different phases: site selection and characterization and initial problem diagnosis, identification of technology option, planning, design and testing of technology options, monitoring and evaluation and impact evaluation (Abad et al. 1995; Paris 2000; lkkaracan and Appleton 1995). This also ensured that the technology development process built on women's traditional knowledge and that the technology addresses a felt need within women's spheres.

- *Increase women's bargaining power by identifying alternative income-generating activities.* Because new technologies have a poverty alleviation goal, it is important ensure that new technologies have potential to improve women's financial status by providing alternative sources of income. In many instances women are more concerned about short- rather than long-term returns to their resources. This was an approach that was applied by the majority of the WID Project Components that developed income-generation/post-harvest technology for women (UNIFEM 1995; Creevy 1996e; Johnson-Welch and Whelan 1996). The Systems Research Targeting Women (WIRFS) also worked with the women to identify new income-earning opportunities such as improved sericulture, backyard poultry and swine production using rice byproducts (Paris 2000). Kabeer (1995) argues that increasing women's economic opportunities can help continue to push back the boundaries of what is considered possible and permissible for women.

- *Build social capital and improve women organizational capabilities for collective relationships*. A large body of literature shows that when women are members of associations, they are more likely to exercise greater bargaining power, both within the household and the community (Kabeer 1995). This argument is supported by this analysis. For example, in all the approaches reviewed, the ability to organize themselves into work groups/associations/women's groups played an important role in improving women's bargaining power and ability to control their lives and increase their remuneration (Carney 1992; Paris 2000). In Guimba, Philippines, women organized themselves into an association to purchase and manage the rice mills commercially. The formation of cooperatives/associations, besides facilitating the ownership of mechanized technologies, also helped spread project risks among group members.

- *Develop specific strategies for women to ensure their access to new technology.* Several strategies were used to increase women's access to technology: Increasing their access to information and technical skills by organizing training workshops and courses specifically for them. The Systems Research Targeting Women (WIRFS) program developed specific programs for evaluating mechanical technologies with the women and training them to ensure that they had access to the required technical information (Amoloza 1998). Other cases encouraging women's full participation were in the technology development process, complemented with training in equipment operation, maintenance and basic management skills (Creevy 1996d). Secondly, the provision of affordable credit increased women's participation because in general poor rural women cannot access credit (Mehra 1996). The majority of the WID Project Component cases introduced a credit or a loan

purchase component to increase women's participation in the program (Johnson-Welch and Whelan 1996).

- ⇨ *Engender the project.* An important part of strengthening the gender component in a project is by increasing the number of women officers or managers and organizing gender-sensitivity training and orientation for field officers. For example, to improve women's access to information and to increase their participation, a WID Project Component case—the oilseed press—increased the number of women field managers employed by the project (Johnson-Welch and Whelan 1996).

- ⇨ *Maintain flexibility within the R&D agenda*. The most successful programs are those where women were given the opportunity to select activities from an array of menu activities (*basket of options*) such as soil conservation technologies, composting, small livestock, vegetables, nurseries and reforestation (Weiss and Paolisso 1996). As part of this basket of options, the programs needed to pay special attention to incorporating alternative income-earning opportunities including both short-term options yielding quick returns for income or home consumption and long-term returns such as improved soil management.

- ⇨ *Incorporate continuous monitoring and evaluation to increase learning from experience.* A key weakness of the approaches reviewed here was that monitoring and evaluation was not built into the technology development process. Monitoring and evaluation involves information gathering, analysis, documentation, assessment and tracking changes at different stages of the research process. It is an important tool for empowering stakeholders at different levels to assess, evaluate and plan initiatives. Monitoring and evaluation helps build ownership of the process and can increase local-level capacity and sustaining partnerships among different stakeholders. Integrating monitoring and evaluation is important for increasing accountability to the community and improving both local and external awareness of key issues.

6 CONCLUSIONS

In this paper we set out to identify what has worked (or not) and why in different approaches used to develop technologies to benefit women and to analyze successful strategies for integrating gender concerns in technology development. To achieve these goals, we conducted a comparative analysis of four approaches that have been applied to develop technologies in agriculture where women have benefited or been adversely affected. The analyses were organized as follows: First of all, we identified four different approaches for review: Commodity Technology Transfer; Systems research targeting women; WID Project Components, adapting postharvest technology for women; and Improving Assets, INM Technology Development. For each approach, case studies were selected and analyzed to derive lessons and experiences with technology innovation and its impact on women. Secondly, the different approaches were examined and compared to identify critical factors contributing to a positive or negative outcome for women.

Our findings show that technical change that will benefit poor rural women must link the following three goals: Improve the productivity of women's labor while addressing the constraints that result from drudgery are crucial to ensuring women can benefit from technical change. Returns to women's labor and their independent income can be achieved through the integration of nontraditional crops and products into female production and postharvest processing activities. We call this the *productivity-enhancing, drudgery-relief strategy*. Integral to achieving these goals is building a strong association between agricultural intensification and increasing the capability of women to rehabilitate the natural resource base on which this intensification depends. There is a close association between increasing labor productivity through intensification in agriculture and increasing the incentive to invest in sustainable natural resource management. Finally, it will be critical for new technologies to address both pre- and postharvest activities (including agro-processing) together in a resource-to-consumption system context. As a result, we developed the concept of a *resource-to-consumption* approach, which brings together the main elements of the production-to-consumption chain used by many of the successful approaches we reviewed, but with the added dimension of natural resource management by women. New opportunities for increasing employment opportunities for women in other parts of the commodity chain can be identified by focusing on the entire resource-to-consumption system.

Finally, our analyses identified seven key strategies that contribute to the design of successful technical change where women have benefited:

- ➢ Use of a resource-to-consumption system, which links the management of natural resources and production aspects to the marketing and consumption of crops and products
- ➢ The inclusion of a research component as well as technology transfer component
- ➢ Taking into account intra-household dynamics in project design and technology development and the differential constraints in access to and control of land between men and women
- ➢ A labor productivity-enhancing, drudgery-relief strategy for introducing new technology

- ➢ Strengthening social capital and organization to enable women to maintain control and improve their bargaining power
- ➢ Building in strategies to ensure sustainability of the project; that is, women retain control of the technology after it becomes profitable.

7 THE NEXT STEPS: APPLYING THE LESSONS

To address new challenges in the face of the feminization of poverty, where rural women are forming an increasing proportion of the very poor, it is crucial for international agricultural R&D centers to design, test and disseminate innovative agricultural technologies and related income-generating opportunities that meet women's special needs and constraints. This strategy would involve the following steps:

- Defining priority geographical areas of the world and within these, "hot spots" with high concentrations of poor rural women and where feminization of agriculture is hypothesized to be under way.
- Conducting a participatory diagnosis of poor rural women's technology needs, constraints and opportunities (women's assets, existing knowledge and skills, market opportunities) in selected hot spots of rural poverty where feminization of agriculture is occurring.
- Developing partnerships with CGIAR and NARS applied research programs with a capacity for developing technologies for women in response to the results of the participatory diagnosis in selected hot spots of poverty and feminization of agriculture. These will aim to increase the competitiveness of women producers by linking interventions to increase labor productivity and decrease drudgery in the entire system: Resource management, production (raw material), processing, marketing and consumption.
- Designing technologies that address both pre- and postharvest (including agro-processing activities) together, because the threats, opportunities and challenges need to be seen in the Resource-to-Consumption System context, from "farmer to dinner plate."

- Establishing a long-term panel of rural women's focus groups to identify and analyze women's changing demand for agricultural technology. A dynamic assessment of changing needs of women to provide regular feedback to technology design in the CG and NARS systems. Proposed activities include:
  - establishing rural women's focus groups in the panel as a network for regular CG and NARS consultation on the diagnosis of needs and the evaluation of technologies,
  - supporting focus groups to conduct regular technology evaluations; synthesize and disseminate the results internationally as feedback to research on technology design, and regular review and exchange of results from focus groups at various levels, and
  - establishing an interactive, user-friendly database on evaluations of technologies for women in partnership with an appropriate institution.

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9 APPENDIX

Appendix 1: Current allocations (% share of resources in 1999) by undertaking, commodity and production sector (*Source*: TAC 2000**).**

1. By Undertaking/ Activity

Increasing Productivity	35
of which:	
-Germplasm Enhancement and Breeding	17
-Productions Systems Development and Management	18
Protecting the Environment	**20**
Saving Biodiversity	**11**
Improving Policies	**12**
Strengthening NARS	**22**
of which:	
Training and Professional Development	8
Documentation, Publications, Information Dissemination	6
Organisation and Management Counselling	3
Networks	4
TOTAL	**100%**

2. By Commodity and Production Sector

Crops	
Banana/Plantain	3.1
Barley	1.6
Bean	4.7
Cassava	5.3
Chicpea	1.9
Coconut	0.3
Cowpea	1.8
Groundnut	2.1
Legume (Soya)	0.7
Lentils	1.2
Maize	7.5
Millet	2.0
pigeonpea	1.0
Potato	6.1
Rice	17.3
Sorghum	2.2
Sweetpotato	2.1
Wheat	8.1
Yam	1.0
Total Crops	**70.0**
Fish	**5.0**
Livestock	**14.0**
Forestry	**12.0**
TOTAL SECTORS	**100%**
(Water	2.8%)

Appendix 2. Roles of women, constraints in increasing agricultural productivity and matching strategies to solve problems in Asia and Africa (*Source*: Nyanteng1985; Paris 2000).

Role of Women	Constraints to Productivity in Africa	Constraints to Productivity in Asia	Strategies to Solve Constraints
Selecting seeds	Not applicable	Access to new information on seed management, post- harvest losses of seed	Include women's criteria in breeding; training in seed production; include women in seed production
Seed storage	Not applicable	Pest damage	Training in seed storage, build on ITK using neem plant
Land preparation in swamps	Drudgery, unpaid family labor, low returns to paid labor	Not applicable	Develop women-friendly labor-saving technologies; e.g. redesigning power tillers to allow women to use them
Purchase of inputs	Not applicable	Access to information on use	Improve knowledge on IPM
Planting, uprooting, Transplanting	Drudgery, lower wages than men	Drudgery, lower wages than men	Develop labor-saving technologies; training in row transplanting; investigate technology on transplanting vs direct seeding
Weeding	Drudgery, lower wages, lack of knowledge	Drudgery, lower wages, lack of knowledge	Develop labor-saving technology; studies to determine opportunity cost of women's labor vs different options for weed control
Scaring birds	Drudgery	Not applicable	Research to address this concern; proper location of rice fields, away from human settlements; oil palm & coconut plantations
Manual harvesting	Drudgery	Not applicable	Develop labor saving technology; e.g. improving access to existing equipment such as small harvesters & threshers
Processing	Drudgery, unpaid labor	Drudgery, unpaid labor	Develop postharvest technology

Appendix 3. Rice and rice related technologies tested at key farming systems research sites, by country, 1987-1994 through the Women in Rice Farming Systems (WIRFs) Network (*Source*: Paris 2000).

Country	Rainfed lowland	Upland	Irrigated
Philippines	Sta.Barbara, Pangasinan	Matalom, Leyte	Guimba, Nueva Ecija
	HYV glutinous rice Rice dehuller Swine-cowpea/sweet potato integration Swine-rice bran	HYV upland rice Micro ricemill	HYV, short maturing mungbeans after rice Rice seed management Micro rice mill
	Badoc, Ilocos Sur		Looc, Calamba
	Seed production of green manure		Integrated pest management
Indonesia	Maros, So. Sulawesi	Batumarta, Indonesia	
	New varieties of soybean after rice Seed management (soybean)	Improved poultry husbandry Post harvest equipment Animal fodder production	
Thailand	Phattalung, Hat Yai	Ban Muang, Khon Kaen	
	Improved poultry husbandry	Improved sericulture	
		Amphoe Phrao, Chiang Mai	
		Improved poultry husbandry	
		Dan Chang Suphan Buri	
		Improved sericulture	
Bangladesh	Sreepur		
	Improved poultry husbandry		
Nepal	Ratnanagar, Chitwan	Naldung	
	Crop-livestock	Agroforestry	
India	Mungeshpur,		
	Fodder crops Rice varieties		

Appendix 4. Summary of case studies reviewed in the WID Project Component approach.

Approach	Country	Technology	Project Objectives	Strategy for Including Gender
1. Developing a technology from scratch specifically for women - new opportunities	Togo, Ghana, Mali (***Source:*** lkkaracan and Appleton. 1995.)	Soybean processing & utilization	Nutritional - to increase protein in diet and to increase soybean utilization	- Introduced a new technology to women - Soybeans introduced as a legume food crop for use in sauces - Women involved in needs assessment, testing & dissemination - Incorporated all aspects of technology development from production to utilization
	Venezuela (***Source:*** Abad et al. 1995)	Hydroponic vegetable production technology for producing lettuce, coriander, chives, curled parsley, chard.	To develop cost-effective growing of vegetables for the market and to generate additional income.	- Introduced new technology to women - Women involved in all aspects of the project - Incorporated all aspects of technology development from production to marketing/utilization
2. Introducing a WID component into an existing project to increase women's participation	Zimbabwe & Tanzania (***Source:*** Johnson-Welch & Whelan 1996)	Oilseed press to extract oil from sunflower seeds	- Nutritional: to increase cooking oil availability - To reduce drudgery by replacing labor-intensive & time-consuming traditional methods	- Introduced a WID component into an ongoing program to increase women's participation - Women were given priority in the credit program.
	Honduras (***Source:*** Creevy 1996c)	Cashew nut & fruit processing	- To promote the cultivation of cashew as a reforestation alternative & as a cash crop - Income generation	- Project initially started as a men's project, then later incorporated women by developing technology for women's role in processing cashew nuts - Project did not have specific strategy for integrating women

3. Developing technology specifically targeted for women's responsibilities: all activities built on traditional roles & responsibilities	Ghana (***Source:*** lkkaracan and Appleton 1995)	Shea butter extraction from tree (*Butyrosperum parkii*)	- To alleviate labor-intensive & time consuming women's work	Technology targeted women and built on women's traditional technology development process
	Nigeria, Ghana, Cameroon (***Source:*** UNIFEM 1995)	Cassava processing - Gari preparation	- Production of alternative crops & products - gari, kokonte - To reduce postharvest losses and increase the storage shelf life - To reduce the concentration of toxins in the raw product	- Women pressured local artisans to develop improved cassava graters - Technology based on manual graters - Formation of cooperatives to own and operate mechanized graters. - Access to credit to purchase factory
	Nigeria (***Source:*** UNIFEM 1995)	Palm kernel processing	- To increase income from kernel products - To alleviate labor-intensive & time-consuming women's work	- Technology targeted women - Project helped women form a group, "Association for Progress," to buy diesel-operated palm kernel cracker for commercial-scale processing
	Tanzania (***Source:*** Creevy 1996d)	Food processing	- To improve women's socioeconomic status - To improve rural women's food processing activities through the dissemination of successful low-cost technologies	- Technology targeted women - Women participated fully in development process - Training in operation, maintenance & basic management skills - Provision of credit through revolving loan fund.
	Bolivia (***Source:*** Barbery & Appleton 1995)	Banana drying in Bolivia	- Improving economic resources - Creating employment opportunities	- Technology targeted women by focusing on their domestic roles - Food processing
	Peru (***Source:*** Creevy 1996b)	Food processing	- To establish workshops for evaluating different food processing technologies, provide a processing service and train in use of the technologies	- Project did not initially target women; this lack of early direction in involving women and defining effective selection criteria hampered one of the main aims of the project, which was to have a major impact on women's lives.

Appendix 5: Women's soil management practices in Maragoli, Kenya (*Source*: Verma 1999).

Soil Fertility		**Soil Erosion**
Organic Fertilizers	Mulching	Trenches
Cow manure	With couch grass	Planting trees
Chicken droppings	With maize stalks/stover	Terraces
Other livestock manure	Mulching	Planting shrubs
Cow urine & runoff from shed	Compost pits	Planting hedges
Improving quality of cow manure through feed	Rubbish collected from yard	
Refuse from household	Rubbish collected from household	
Refuse from farm		
Green manure		
Inorganic fertilizers		
Store-bought	Use of Crops	
Chemical fertilizers from coops/cos.	Crop rotation	
Top dressing in planting holes	Intercropping	
Combination	Rotational bush fallowing	
Organic + inorganic fertilizers		

FUTURE HARVEST

Future Harvest is a non-profit organization that builds awareness and support for food and environmental research for a world with less poverty, a healthier human family, well-nourished children, and a better environment. Future Harvest supports research, promotes partnerships, and sponsors projects that bring the results of research to rural communities, farmers, and families in Africa, Latin America, and Asia. It is an initiative of the 16 food and environmental research centers that are primarily funded through the Consultative Group on International Agricultural Research.

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CGIAR

The Consultative Group on International Agricultural Research (CGIAR) works to promote food security, poverty eradication, and sound management of natural resources throughout the developing world.

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In recent years the CGIAR has embarked on a series of Systemwide Programs, each of which channels the energies of international centers and national agencies (including research institutes, non-government organizations, universities, and the private sector) into a global research endeavor on a particular theme that is central to sustainable agriculture, fisheries, and forestry.

PRGA

The purpose of the CGIAR Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation (PRGA Program) is to assess and develop methodologies and organizational innovations for gender-sensitive participatory research and to apply these in plant breeding, and crop and natural resource management.

The PRGA Program is cosponsored by 4 of the 16 centers that make up the CGIAR: the International Center for Tropical Agriculture (CIAT), which serves as the convening center; the International Maize and Wheat Improvement Center (CIMMYT); the International Center for Agricultural Research in the Dry Areas (ICARDA); and the International Rice Research Institute (IRRI).

PRGA Program activities are funded by Canada's International Development Research Centre (IDRC), the Ford Foundation, the Rockefeller Foundation, and the governments of Germany, Italy, the Netherlands, New Zealand, Norway, and Switzerland.

CIAT

CIAT's mission is to reduce hunger and poverty in the tropics through collaborative research that improves agricultural productivity and natural resource management. Headquarters in Cali, Colombia.

CIMMYT

CIMMYT is a nonprofit scientific research and training organization engaged in a worldwide research program for sustainable maize and wheat systems, with emphasis on helping the poor while protecting natural resources in developing countries. Headquarters in Mexico City, Mexico.

ICARDA

ICARDA's mission is to improve the welfare of people through agricultural research and training in the dry areas in poorer regions of the developing world. The Center meets this challenge by increasing the production, productivity and nutritional quality of food to higher sustainable levels, while preserving or improving the resource base. Headquarters in Aleppo, Syria.

IRRI

IRRI is a nonprofit agricultural research and training center established to improve the well-being of present and future generations of rice farmers and consumers, particularly those with low incomes. It is dedicated to helping farmers in developing countries produce more food on limited land using less water, less labor, and fewer chemical inputs, without harming the environment. Headquarters in Los Baños, The Philippines.

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