Gender, Household Composition, and Adoption of Soil Fertility Technologies: A Study of Women Rice Farmers in Southern Senegal

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Introduction

If as claimed by the Food and Agriculture Organization of the United Nations women grow up to eighty percent of the food produced in Africa, then targeting them during research, technology development and dissemination makes sense. [1] In order to do so, it is necessary to recognize that not all women farmers are the same with respect to their access to resources, or their goals and motivation. This research shows how an additional factor—household composition—can determine which subgroups of women farmers can adopt technologies aimed at increasing their productivity, under what conditions.

Adoption by farmers is the ultimate test of research and technology in agricultural development, and should be the ultimate goal as well. To meet this goal these processes need to be designed and carried out with end users in mind. This means understanding the target audience before researching and developing new technologies. In Africa, this means focusing on women farmers and understanding their livelihood options and resource allocation decisions. In addition, it means exploring household composition as a key factor that can increase or decrease the likelihood of adoption of technologies by women farmers.

Smallholder farmers manage factors of production—land, labor, and capital—under conditions where the only constant is change. Better than anyone, they are able to identify and explain the defining variables, or drivers, of these seemingly unpredictable and diverse systems. [2] The keys to discovering and decoding diversity lie with the farmers, men and women, and are often hidden within their objectives and motivation.

Diversity in livelihood activities, or systems, examined at the national level may indicate activities chosen based upon biophysical, ecological or policy differences. Diversity between livelihood systems at the community or regional level may indicate strategies chosen based upon cultural differences. [3] Diversity among households within the same livelihood system can indicate livelihood strategies chosen based upon household composition, a determinant of labor availability and consumption requirements. Thus efforts to improve conditions in any system must begin with an awareness of what exists, where farmers want to be, which avenues fit within their norms and are acceptable to them, and what resources their households can devote to these endeavors. [4] In this case, livelihood systems are defined as the range of activities to which a household has access in the effort to meet their needs, while livelihood strategies are the specific resource allocation decisions made by each household over time.

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This research was undertaken to understand the nature and specifics of livelihood systems of Fulbe farmers in southern Senegal and their strategies, practices, and activities. [5] The following case study illustrates that once a specific livelihood system is delineated, there remains a range of activities women farmers have available to them. It then illustrates the role of household composition in determining livelihood strategies pursued by women farmers. Finally, this paper suggests that to correctly identify and effectively address the needs of women farmers, each member of the development community (policy makers, researchers, and field workers) must work with them in mind.

GENDER

When examining livelihood strategies in subsistence farming systems in Africa, a distinct and crucial element of decision making is gender. Oakley declares that "Gender differences . . . arise from the socially constructed relationship between men and women." [6] The nature of these relationships varies greatly by culture and social system, and serves to create distinct roles and responsibilities often referred to as gender roles or gender division of labor. These distinctions are shaped by various environmental factors including ideological, religious, economic and cultural factors; and help define resource allocation and access between men and women. [7]

The Women in Development (WID) literature explains how women in developing countries (farmers, workers, and business people) are often 'invisible', and as such their contribution to the household as a production unit is often ignored, overlooked or underestimated by observers. [8] Misrepresenting women's role in the household leads to misunderstanding of decision making within the unit. This situation is perpetuated by development professionals who collect data based upon a person's perceptions of his or her role within the household rather than their actual participation in activities. [9] In this case, women often refer to their husbands as the primary producers and themselves as only supporting the household. As a result, women's participation is grossly underreported or misunderstood and development efforts ignore a major group of producers. [10]

RESEARCH SETTING

Field research was done in a small community of subsistence farmers in the Upper-Casamance region of southern Senegal. In many ways, this particular area does not resemble Senegal north of the Gambia or areas closer to the coast, and has not been studied to the same degree as those areas. For example: in biophysical terms, rainfall is higher in the south; economically speaking, incomes tend to be higher in the north; and in terms of ethnicity, Wolofs and Sereers are the majority in the north but few live south of the Gambia. This diversity is reflected in the slight-to-nonexistent connection that this area has to political institutions in Dakar and resulting infrastructure and development.

The Upper-Casamance is considered tropical with one rainy season from July through November. In a typical year the region receives 1000 mm of rain with August and September being the wettest months. The dominant geographical feature in this area—the Department of

Kolda—is the Casamance River. Villages in the valley are agrarian in nature and rely on the river for water for their livestock, fishing, some transport, market gardens, and occasional dry season rice plots. Several ethnic groups inhabit this area including the Fulbe, Mandinka, and Diola. Polygyny is an accepted practice in this predominantly Muslim region. [11]

Subsistence farmers in southern Senegal produce most of what they eat (cereal grains, legumes and vegetables) and have limited access to cash for the purchase of food or other inputs. Their diet consists mainly of rice, maize and millet as staples accompanied by various sauces based upon locally produced groundnuts, hibiscus leaves, and okra. In addition to food crop production activities, various domestic or constant household tasks consume the scarce resources of these villages and households. Land tenure is communal with male village elders deciding which households have access to which areas of land. Households are assigned areas of upland fields for production of maize, millet, sorghum, and groundnuts to be cultivated at the discretion of the male head of household. Each household is also assigned areas suitable for rice production, to be cultivated at the discretion of the senior women in the household. Limited labor—rather than land scarcity—typically prevents men and women from expanding their cultivated areas.

Men in this area are responsible for producing upland cereal grain and pulse crops while women typically focus on rice, specialty crops, and virtually all domestic activities of the household. Staple grains produced in this area include rice, millet and maize while groundnuts are the most widely grown cash crop. Men often opt to work with male relatives to cultivate communal maize or millet but rarely share labor or cash benefits of groundnut production. Many farmers, usually women, produce specialty crops—mostly vegetables—for home consumption and market. The limited use of animal traction and a distinct division of labor with respect to crop production characterize this system.

Fulbe farmers in this region have limited access to cash generating activities. Men typically produce groundnuts as their main income generating activity while women often have no regular source of cash income. This low level of commercialization is more typical of local Fulbe than other local ethnic groups whose production activities are typically more diversified.

Perhaps the most crucial aspect of food security in this region is the fact that food security is ultimately communal; no one in the village starves if someone in the village still has food or resources. Households are expected to produce for and feed themselves, but in the event of crop failure, food shortage, or extraordinary stress, the village will pool resources and adopt village strategies for survival. In the event of food scarcity, Fulbe may slaughter or sell livestock to survive stressful periods.

LIVELIHOOD SYSTEMS

The main agricultural activity of Fulbe women is rainfed rice production, done entirely by hand without the benefit of mechanization or hired labor. Women's performance of this activity is crucial to them, not only for food security, but because they derive prestige among their peers from being superior rice producers. As such, in the eyes of the community, their main contribution to the household is the quantity and quality of rice they are able to provide. These women each work their own rice plots, from soil preparation through harvest, and

prepare the rice as meals for their families. When a woman's rice runs out, she must cook millet, or rice bought by her husband. Her perceived inadequacy is noticed within the village, especially if other women (co-wives) in her household are still preparing rice they have produced.

The intrinsic value attached to rice encourages these women to devote most of their rainy season labor to this activity and not invest significant time in other agricultural activities, such as vegetable or groundnut production. Rice takes on greater importance for Fulbe women as the only staple that they control completely. Fulbe men distribute other food—millet, maize, sorghum and groundnuts—to women for daily preparation without consideration of budgeting. Ultimate responsibility for ensuring that households eat at culturally acceptable levels falls to the men; and they must make up for any production (cereal grain) shortfalls during the year. Women are expected to grow rice and secure items for relish but are not expected to have cash to contribute toward the purchase of food. There exists a rigid division of labor between men and women and very few production or domestic activities are shared within the household unit.

HOUSEHOLD COMPOSITION

Examination of households within a village may show similarities in livelihood systems, natural resource availability, ecological conditions, constraints and even culture; but this can be misleading. Within any community, each household is distinct due to variations in resource availability and consumption requirements as determined by its composition at any given point in time. Households consist of individuals, each of whom require of and contribute to the household at differing levels as they age. Thus, no two households will have either the same exact needs or the same exact resources with which to meet them. This diversity necessitates complex resource allocation decisions, and these households persist by adopting complex and diverse strategies to exploit available resources. [12] Many of these strategies are based upon manipulation of their own labor to meet their objectives, which range from reproduction of the family unit without regard to profit maximization to profit maximization. [13] Not only does composition determine resource availability and consumption but also determines which livelihood strategies can be pursued and to what degree. This is especially true within livelihood systems with distinct gender divisions of labor.

Given that individual households in the study area undertake production activities as a unit, they rarely hire labor and seldom exchange labor. Thus their stage in the development cycle, or their structure, determines their supply of labor at a given point in time. As households age, a series of changes likely takes place; initially children are born into the household directly claiming women's time as childcare providers and indirectly claiming men's time via increased food demand coupled with reduced female production labor. As children mature, their labor is consumed as available; boys begin helping with livestock care and fieldwork while girls typically begin performing household tasks such as childcare, food preparation, and cleaning. At some point male heads of household may opt to take an additional wife. Her addition to the household immediately increases labor available for rice production and/or reproduction activities. Eventually, household heads begin planning for one

of their children (usually male) to marry and stay in the village to support his parents as they age. In the event there are several male children in the household, one or more may opt to leave his home village, at marriage, in search of new land to cultivate.

LIVELIHOOD STRATEGIES AND HOUSEHOLD STRESS

As household members age—regardless of sex—their roles and responsibilities to the household change, as well as their nutritional requirements. Previous studies have examined the effects of changes in household composition and suggest that among these changes, reproductive demands influence women's involvement in production activities. [14] These studies consider how pregnancy, childbirth, and lactation influence the amount and quality of labor a woman can devote to production tasks. Although cases from Latin America suggest that husbands and older children often share in child care responsibilities and that women are inclined to take their small children to the fields, the number and ages of the children dependent on a woman may impact her ability to work. [15] Consequently, every household will experience some degree of stress due to changing demographics in the household, especially in cultures where men are rarely involved in childcare. A household must adopt various livelihood strategies over its lifetime based upon the amount and quality of labor—the supply side—as determined by the number of members present and their ability. Consumption requirements—the demand side—also help determine livelihood strategies.

The ratio of labor availability to the burden of consumers within a household can be measured and provides an indicator of the level of stress that households endure and must manage. This stress, referred to in this study as energy stress, is the burden that falls on producers who must provide for additional consumers. An unmodified 1:1 consumer to producer ratio implies that for every consumer in the household there is one producer. A household with a 1:1 consumer to producer ratio can be considered to be experiencing relatively low energy stress, because for each person consuming from the household stores, there is one person producing or contributing. However, an unmodified consumer to producer ratio, such as introduced by A.V. Chayanov, calculated using an either/or to indicate status as a consumer or producer, does not sufficiently illustrate fluctuating energy requirements or availability based upon gender, age and physical activity levels found within the household. Therefore, a modified consumer to producer ratio was calculated here, based upon aggregated annual household energy requirements, to graphically demonstrate fluctuating household stress levels.

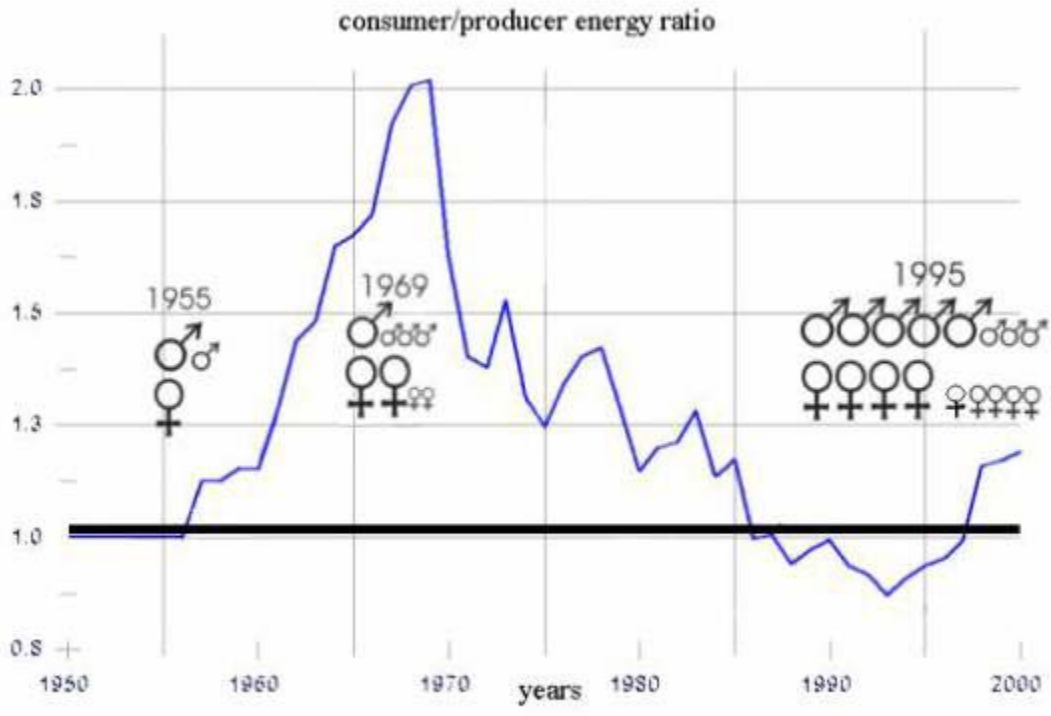
The modified consumer-producer ratio represents energy requirements of the consumers divided by the energy requirements of the producers. It is based upon the World Health Organization recommended daily caloric intake, and incorporates the nutritional differences in sex, reproductive status, age, and physical activity levels in adults and children. [16] Therefore the modified ratio reflects the differences in nutritional requirements found between adults and children, men and women, pregnant and lactating women, and various levels of physical activity.

Graphing longitudinal energy stress—spanning the life of a household—illustrates increases and decreases in stress endured by a household due to changing composition. Figure 1 represents the severity of energy stress experienced by a Senegalese household since its

inception nearly fifty years ago when the male head of household left his village of birth and took his first wife. Three points in time (1955, 1969 and 1995) are of particular interest, indicating how household composition affects livelihood strategies in subsistence farming households.

It is natural to assume that a household will experience the highest degree of energy stress when it must provide for the largest number of members; this however is not always the case. With energy stress based solely upon the number of household members, the household depicted in Figure 1 would have encountered the most energy stress during 1995 when it contained 17 members. However, at this time, this household had a relatively favorable consumer to producer ratio (15:12) even though the household contained the greatest number of members since its inception. Among the household members in 1995 were: the male head of household, his three wives, three adult sons, an adult nephew and his wife, and various children. Therefore, household composition, disaggregated to reflect gender and age, is more important than the sheer number of members a household contains at any given time. In addition to the number of consumers and producers in the household, intra-household diversity in the form of age, sex and physical activity level becomes a crucial factor when determining where energy stress falls.

Figure 1: Household Energy Stress Curve



In Figure 1 the horizontal line shows a 1:1 consumer to producer ratio, for every consumer in the household there is one producer. For example, an adult couple—with no children—who are both engaged in production activities while consuming from the household exhibit very little energy stress. This scenario is illustrated in Figure1 by the horizontal line. The energy, in kilocalories, required by the consumers is roughly equal that required by producers. Divergence from the horizontal line reflects a change in household composition: numbers, ages, reproductive status, or physical activity level of members and therefore an alteration in the level of energy stress.

Any upward deviation implies an increase in household energy stress, while any downward trend denotes a decrease in energy stress. In other words, when household composition results in a peak above the line, the household is exhibiting an unequal consumer to producer ratio in which the energy required by the consumers is greater than that required by the producers. In addition to sustaining him or herself, each producer is also responsible for supporting additional household members (consumers), who are most likely children, elderly, or adults who are completely dependent upon others and unable to contribute to household production. This shifting balance between consumers and producers is key to understanding smallholder systems that are characterized as relying on their own labor. [17]

When household composition results in a dip below the horizontal line, the household is in a situation where the energy of the producers is greater than that of the consumers. Household members engaged in off-farm employment far from the village frequently cause this situation. These individuals do not figure into the consumer calculation for the household because they are physically absent, thereby consuming few if any resources. They do figure into the producer calculation because their energy is used to contribute remittances to the unit.

In 1955, the household in Figure 1 was "new" or just formed. It was under relatively low total energy stress with three consumers to two producers. However, this is misleading given the gender division of labor within the household. The woman's responsibility for domestic tasks left her with limited time to devote to rice production. Therefore the majority of production activities fell to the other producer in the household, the man.

In 1969 this household experienced its highest level of energy stress to date because of an unfavorable consumer producer ratio, 8:3 with eight consumers, including five children and only three producers. However, in this instance, the household had two adult women who could manage their labor to accomplish both domestic and production activities.

In 1995, the study household could be considered mature with a large population. Based solely on bodies present, one could assume that high energy stress prevails. Not so. At this time there were seventeen household members, fifteen of whom were consumers, relying on twelve producers. Due to birth order in the early years of this household, the head of household opted to send sons to seek off-farm employment thereby lowering consumption requirements and sending remittances.

As shown by Figure 1, stress due to changes in household composition is cyclical. Point-in-time examination of resource availability within a household, without regard to current or past stress levels, may only tell half of the story. Modified consumer to producer ratios illustrate the need for attention to constantly changing stress levels, but do not show how differentiated or disaggregated stress affects women and men differently. Longitudinal examination of energy

stress can mask how changing composition affects different individuals. Thus it is necessary to conduct gender-specific examination of these units over time to determine who, if anyone, bears the brunt of a particular situation.

DISAGGREGATED HOUSEHOLD STRESS: LINEAR PROGRAMMING

Linear programming is a method of maximizing the outcome of one or more objectives relative to the constraints placed upon those objectives. These outcomes depend upon the household's objectives. For example, consider a household seeking to maximize its cash generation while meeting some minimum food requirement. The linear program (LP) model considers how much labor, land, cash and other resources the household has available. It then considers the amounts and combinations of those resources the household must use to meet defined subsistence requirements. Finally, using resources remaining after satisfying these minimum household needs, the model maximizes (or minimizes) another household goal or objective such as food stores, discretionary cash, or leisure time. To create LP models, data concerning specific activities are collected in rates including time, labor or cash needed to perform a particular activity per area of land, person or household and corresponding outputs. LP models, validated to reflect real conditions, can indicate where energy stress may affect livelihood systems, activities and strategies; and with gender disaggregated data, can show gender-specific labor shortages or surpluses. LP models can also uncover seasonality of energy stress and its differential impacts on men and women.

An LP model was created to simulate the livelihood system of the Fulbe study household in Figure 1 at three different points in time, 1955, 1969 and 1995. Results are presented in Table 1. Total available female labor in 1955 is taken up by household activities such as childcare, food gathering, preparation, serving and clean up, water collection, laundry, and fuel wood collection. Clearly, the one adult woman in this household at this time has no labor to devote to rice production. The burden of production falls to the man and his labor alone meets household consumption (energy) requirements. He uses the cropping mix depicted in Table 1. With this household composition he cannot afford start up costs for groundnut production and would have to borrow money or seed. This is a likely strategy but when provided with additional cash for increased groundnut production his labor is constrained at current levels. This household has very few resources available and energy stress on both the male and the female severely limit their options. Groundnut production with available labor generates the household's annual income, equivalent to $175.

Table 1: LP: Production and resource allocation for study household

Output	1955	1969	1995
Off-Farm Workers, Number of Men	0	0	2
Groundnuts, Area Cultivated in Hectares	1.1	.49	6.7
Cereal Grains, Area Cultivated in Hectares	.88	1.5	1.2
Rice, Area Cultivated in Hectares	0	0.6	2.7

Unused Male Labor, Days Per Year	0	0	0
Unused Female Labor, Days Per Year	0	0	102
Year End Cash in CFA* 500 CFA=1$ US	87,791 ($175 US)	36,089 ($72 US)	652,387 ($1,304 US)

*Central West African Francs

The study household experiences its highest energy stress in 1969 (see Figure 1) when there were two women and one man to produce for themselves and their five children. A linear program simulating this household composition shows that the household could expect to earn less year-end cash in 1969 than they did in 1955. Increased female labor availability for rice production has reduced the proportion of total cereal grains that the male must produce, but due to greater overall cereal requirements, the male devotes more of his available labor to this endeavor. Male labor is no longer producing the entire cereal grain requirement, yet year-end cash has decreased because he has less time to devote to groundnut production, his only cash generating activity. In 1969 this household generated the equivalent of $72.

Figure 1 shows that in 1995 this household experienced low energy stress, falling below the horizontal (1:1) line for the first time since its inception. There are now seventeen household 'members', fifteen of whom are consumers, relying on twelve producers. Based upon 1995 household composition, the LP predicts (see Table 1) that due to ample male labor, two men can seek off-farm work and send remittances. The benefit of this strategy is two-fold: the household need not meet their consumption requirements and they remit cash. The remaining male labor in the household produces the minimum cereal grain required of them (to achieve a culturally acceptable diet) and devotes the rest of their labor toward groundnut production to generate cash. Available female labor (four adults) is not a limiting factor in this household in 1995. In fact, at year-end, the LP model shows 102 days of unused female labor (see Table 1). As soon as all domestic and production requirements utilizing female labor are met, unused labor begins to accrue because this model offers no alternative female activities, cash generating or not. The excess female labor would likely be devoted to additional rice production. Although there are many mouths to feed in 1995, there are a significant number of hands to do the work and the household generates the equivalent of $1,178.

Managing stress due to household composition has many peripheral effects on a household. Consider for example the diet of a household with abundant male labor and scarce female labor. They rely mainly on the crops, maize, millet and groundnuts produced by men and have limited access to rice, vegetables or other crops produced by female labor. On the other hand, a household with abundant female labor would produce greater quantities of rice, freeing up male labor for income generating activities, and possibly leading to increased food security. Households typically gear their cereal cultivation toward a 'culturally acceptable' diet whereby two out of three daily meals are based upon millet or rice. A steady diet of either rice or millet is not considered culturally acceptable and is usually indicative of stress or the

inability of a household to me its needs. Therefore, household objectives in this system include attaining a culturally acceptable diet for as much of the year as possible.

Periodic stresses such as drought, unfavorable market conditions, or death of key individuals within the household call for strategies that get the household through the indeterminate stress period. Such strategies include: selling cattle, arranging marriages of daughters, sending men to work off-farm or adaptation of production activities to existing conditions. Cyclical stresses caused by illness, pregnancy or prolonged absence from the village of a key producer is also managed. In such cases, augmenting or replacing labor from nearby, existing pools is used to reduce stress until it has passed. Any acceptable strategy or combination thereof would, by definition, be appropriate to the culture.

Realignment of households in family groups is a typical strategy of household heads to mitigate stress, especially in times of scarce labor. In addition to manipulating inter-household relationships, heads of household manipulate conditions within their own households to alleviate stress. Men in these households manage the labor bottleneck at soil preparation and seeding time by sharing resources. Women typically manage it by finding another female, usually a young relative from another village, to help with their household chores thereby freeing up their own labor for production activities.

WOMEN AND SOIL FERTILITY

Given the complexity of the livelihood system and the unpredictable nature of household composition and stress, targeting women farmers is very much like trying to hit a moving target. The task becomes even more difficult when working with resource-limited farmers with little or no access to cash. Nonetheless, development professionals must commit to understanding livelihood systems within which women work, as well as their goals and motivation, in order to create technologies and recommendations that address real needs.

Addressing the issue of soil fertility for women's crops and fields in the study village, the following questions were posed, given that Fulbe women do not currently use any chemical fertilizer but have cultural motivation to maximize production, 1) what do they do to increase soil fertility? 2) If a project were started to introduce fertilizer on credit for village women, would they participate?

This research and analysis was meant to assess the likelihood of women's improving soil fertility by use of any method, including organic or chemical. A rapid assessment of the area showed that women's primary, and sometimes only, production activity is rice cultivation. The likelihood of women increasing their rice yields by incorporating chemical fertilizers, received on credit, into their production practices was examined.

Fulbe women have little or no access to cash with which to purchase or repay loans for fertilizer. Given their culturally sanctioned priority of increasing rice production, they would likely be interested in increasing their yields. With few other production activities available to them, Fulbe women would incorporate fertilizer into rice cultivation *only if it were affordable.*

Use of chemical fertilizers by any farmer in this area is uncommon due to limited availability and/or high cost. Regular chemical fertilizer use by women, on rice, is extremely rare and dependable or affordable supplies are only two of many barriers to adoption. Women

save seed from year-to-year and according to cultural norms, do not sell rice. Thus, a cultural change introducing cash inputs into rice production is highly unlikely. Of equal importance is that women do not produce rice as a cash crop, nor do they invest money in rice cultivation. One practical obstacle is the probability that male household members would appropriate fertilizer acquired by women and use it on their cash crops. As previously stated, Fulbe men are ultimately responsible for household food security and could therefore compel women to 'give up' their fertilizer for use on cash crops. Finally, chemical fertilizer is available only at high transport costs in the area.

How then could a soil fertility improvement project help these women? Based upon production and household data, LP models were created to simulate production systems. Once the model was validated to reflect existing conditions, "what if?" questions relative to the hypothetical project were posed and the model run again to generate another solution. Among the obvious questions to be asked were (a) would women use chemical fertilizer on their rice if it were available? (b) how could they access it most effectively; via a grant (free fertilizer) or credit? (c) which households could take advantage of such a project and increase their yields, profits or food production? and (d) which households would benefit most from fertilizer use?

In response to the first question, of course women would use fertilizer to increase production if they could afford it and if it fit within their existing production schemes. Were fertilizer given as a grant, assuming the men did not appropriate it from them, women would incorporate it into their agricultural practices. Were women given fertilizer and able to convince men that the resulting increase in rice production would lessen their burden of millet and maize production, the women might be able to keep a portion and apply it to their fields. Fulbe women have limited access to cash however, so any purchase of fertilizer with cash up front is likely out of the question. As cash is not invested in non-cash generating crops, and these women do not sell their rice, it would prove difficult for them to pay back a loan in cash.

In response to the second question (how could women access chemical fertilizer?), potential solutions are 1) giving them a grant; and 2) allowing women to fertilize rice on "credit", paying back a certain quantity of their harvest—in lieu of cash—in return for the fertilizer they receive. Both of these solutions were explored using LPs. Different costs in fertilized rice, or different 'interest rates', calculated as different percentages of yield to be returned to repay the credit, were calculated to determine if and when various households could and would participate in such a project.

In addition to expected increased yields of fertilized rice, increased labor is also associated with fertilized rice production as compared to traditional rice production. Soil preparation and seeding time would be comparable for fertilized and non-fertilized rice. However, fertilizer use would increase weed growth and thus women's weeding time. Due to higher yields, harvest time would also be increased.

After the procurement of chemical fertilizer, participation in this project depends upon female labor availability. Thus the keys to adoption of fertilized rice in these scenarios are the price of fertilizer and access to female labor as determined by household composition. As such, three scenarios have been created to represent various "costs in rice" for households of various compositions.

The first scenario (Table 2) depicts the 1955 household of Figure 1 comprised of *one woman, one man and one child*. In this model, all available female labor is consumed by domestic activities, leaving none for any sort of rice production regardless of cost. A grant or free fertilizer would not increase women's rice production in this household unless more female labor was available. In this household all consumption requirements are met by male cereal grain production and all available female labor is dedicated to household tasks with none available for rice production of any sort.

Table 2: Scenario one: Adoption of fertilized rice

Number of Women in Household	Available Female Labor	Labor Consumed by household	"Cost in Rice" of credit	Traditional Rice Grown	Fertilized Rice Grown	Unused Female Labor
1	330 days	330 days	0 kg/ha	0 ha	0 ha	0 days

In summary, due to household composition—and the resulting scarcity of female labor—there is no rice grown in this scenario and all female labor is consumed by domestic tasks. Thus, this household would be unable to benefit from this project and should not be targeted at this point in time.

The second scenario (Table 3) depicts the 1969 household of Figure 1 comprised of *two women, one man and five children*. In this case, there is available female labor in excess of household domestic requirements. If there were no cost for fertilizer—if it were free—and women kept the total they produced, this household would cultivate 0.5 hectares of fertilized rice. They would still opt to produce 0.5 hectares of fertilized rice if they had to return 200 kg/ha, or one-sixth of the expected yield. However, at a 400 kg/ha cost in rice, women in this household would revert to their traditional practices, and cultivate 0.6 hectares to meet household consumption needs without using fertilizer.

Table 3: Scenario two: Adoption of fertilized rice

Number of Women in Household	Available Female Labor	Labor Consumed by household	"Cost in Rice" of credit	Traditional Rice Grown	Fertilized Rice Grown	Unused Female Labor
2	660 days	570 days	0 kg/ha	0 ha	0.5 ha	0 days
			200 kg/ha	0 ha	0.5 ha	
			400 kg/ha	.6 ha	0 ha	

This implies that producing traditional rice is a more efficient use of labor at times when female labor is scarce and fertilizer 'costs' are high. The household invests female labor in fertilized rice cultivation (depending on the "cost in rice" of fertilizer) until yields drop below yields of traditional rice. If returns to labor investment in fertilized rice are sufficient, this household could participate in and benefit from this project. In summary, women cultivate at least 0.5 hectares of rice and all female labor would be used regardless of adoption of the new technology.

The third scenario (Table 4) depicts the 1995 household in Figure 1 comprised of *four women, five men and eight children*. In this case, there is available female labor in excess of household domestic requirements. If grants of fertilizer were made to the women in the household, and women kept the total they produced, this household would cultivate 1.8 hectares of fertilized rice. At a cost of 200 kg/ha, they would produce 2.2 hectares of fertilized rice. At a cost of 400 kg/ha, or one third of expected yields, this household would still grow fertilized rice amounting to 2.7 hectares. It is not until the cost in rice for fertilizer reaches near 600 kg/ha, or half of expected yields, that this household would revert to producing traditional rice to meet their consumption demands.

Table 4: Scenario three: Adoption of fertilized rice

Number of Women in Household	Available Female Labor	Labor Consumed by household	"Cost in Rice" of credit	Traditional Rice Grown	Fertilized Rice Grown	Unused Female Labor
4	1320 days	810 days	0 kg/ha	0 ha	1.8 ha	183 days
			200 kg/ha	0 ha	2.2 ha	118 days
			400 kg/ha	0 ha	2.7 ha	20 days
			600 kg/ha	2.7 ha	0 ha	102 days

With relatively abundant female labor, the women in this household are able to take advantage of a credit project and could pay back a considerable sum in return for fertilizer. According to the LP, regardless of the type of rice produced, these women grow between 1.8 and 2.7 hectares of rice, without ever consuming total female labor.

The three scenarios set out here indicate that as available female labor in the household increases, households are more likely to choose fertilized rice and can afford to "pay back" more rice. Thus, household composition is a determinant of whether or not participation in a soil amelioration project for women is possible and to what degree. Only the household in the third scenario is really able to take advantage of a project offering fertilizer on credit for increased rice

production. This option would be crucial in the study village as there are few if any cash generating activities for women, nor cultural incentives to lure them away from rice cultivation.

The hypothetical project presented here only addresses soil amelioration for women's rice production because of the limited livelihood options available to them. However, as biophysical and socioeconomic conditions in the area change, women may need, opt, or be encouraged to alter their production activities in search of income generating opportunities. In this event, policy makers and development professionals must plan with the knowledge that not all women farmers are the same. The scenarios presented here clearly indicate *which* women would have the resources to participate in the project, and to what degree. Similar assessments and analysis should be done for any development effort, regardless of whether or not it is designed specifically for women.

IMPLICATIONS

In the previous scenarios linear programming models were used to show how changes in household composition impact women and dictate their availability for certain roles within the household. In order to understand resource allocation decisions in the household, development professionals must acknowledge differential decision-making with regard to gender. In the Casamance, Fulbe women make their respective production and resource allocation decisions based upon their own criteria, and their knowledge of a whole set of complex issues affecting their household's survival.

Development professionals must have a clear understanding of their target audience, including *all* decision makers, if they are to understand farmers' constraints to adoption and causes of food insecurity at the household level. Thus technologies and recommendations must be tailored to specific types of households and decision makers—including women—matching their available resources and fitting within their existing schemes. By disaggregating household stress by sex and age, linear programming models can help development planners formulate policy interventions that help women better manage the complexity of issues they face.

The diversity of livelihood strategies found across time, within the households in this study illuminates the fact that not all women engaged in agricultural production can afford to follow the same path toward survival. Rather, the types and quantities of resources women have at their disposal, to meet household demands, determine which path is followed. By misunderstanding this complex set of conditions, researchers and change agents might aim a brilliant solution at the wrong audience or address the wrong problem altogether.

Notes

1. FAO 2002, www.fao.org/Gender/en/agrib4-e.htm.
2. Chambers 1997.
3. Jochim 1981, and Goody 1989.
4. The author developed this reasoning while comparing the study Fulbe village with a neighboring Mandinka village. The two villages, side by side across the river, shared

agro-ecological and bio-physical conditions yet their livelihood systems were different; for brevity we do not discuss the Mandinka village livelihood system in this paper (see Sullivan 2000). Within the livelihood system of the Fulbe village, economic factors (household composition) determine household decision making strategies. We are looking at different levels or scales of analysis, and so there is not a contradiction between culture impacting livelihood systems and economic factors and household composition impacting livelihood strategies chosen within that system.

5. In this case, livelihood systems are defined as the range of activities to which a household has access in the effort to meet their needs. Livelihood strategies are the specific resource allocation decisions made by each household over time, within the existing, possibly evolving, livelihood system.
6. Quisumbing 1996.
7. Quisumbing 1996
8. Safa 1995.
9. Deere, et al. 1990.
10. Deere, et al. 1990.
11. The existence of female-headed households in this area is extremely rare and there were none in the study community. In the case of divorce, a wife typically returns to her village of birth while the husband remains in his. If a woman's husband dies her options are: 1) become a wife of her husband's brother or other male relative; 2) return to her village of birth; or 3) become part of an adult child's (usually a son) household.
12. Chambers 1997, Koenig, Diarra and Sow 1998, and Netting 1983.
13. Norman 1983, and Shaner, Phillip and Schmehl 1982, and Thorner 1986 and Goody 1989.
14. Buvinic 1990, and Hamilton 1995.
15. Stark 1979, and Hamilton 1992, and Hamilton 1995.
16. FAO/WHO/UNU 1985.
17. Chayanov 1966.

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