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Research

The Dynamics of Social Capital in Influencing Use of Soil Management Options in the Chinyanja Triangle of Southern Africa

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ABSTRACT. Social capital has become a critical issue in agricultural development as it plays an important role in collective action, such as, management of common resources and collective marketing. Whilst literature exists on the role of social capital in the use and adoption of improved agricultural technology, such literature is fraught with issues of the measurement of social capital beyond membership of farmers in groups. We hypothesized that different types of social capital influence the adoption of soil management options differently. This study looked at the measurement of social capital, differentiating between the main types of social capital and employed factor analysis to aggregate indicators of social capital into bonding, bridging, and linking social capital. Using logit analysis, the role of these types of capitals on influencing use of different soil management options was analyzed. The study found that bonding, bridging, and linking social capital all influence the adoption and use of different soil management options differently, a trend that might be similar for other agricultural technologies as well. The study recommends more research investments in understanding the differentiated outcomes of these forms of social capital on use and adoption of technologies to further guide agricultural interventions.

Key Words: *gender; smallholder farmers; social capital; soil management*

INTRODUCTION

In rural areas of sub-Saharan Africa (SSA), most people depend on agricultural production for their livelihoods. In the last three decades, numerous advances have been made in agricultural research and technology generation for increasing agricultural productivity in SSA, and for ensuring sustainable use of scarce natural resources. Adoption of such technologies has the potential to increase yields and reduce poverty, as seen in South Asia and East Asia where per capita gross domestic product (GDP) rose annually by 2.3% and 3.1%, respectively, over the last three decades (World Bank 1996). An integral part of sustained poverty reduction efforts is improved soil management and sustainable use of natural resources (Kabubo-Mariara et al. 2007, Nkonya et al. 2004). Andriesse et al. (2007), in an analysis of reports by bilateral and multilateral donors and development agencies on the role of agriculture in stimulating pro-poor economic growth and reducing hunger, found that most reports recognize the need for priority investments in the restoration of soil fertility and sustainable use of natural resources. Investments in soil management options, however, need to be accompanied by farmer capacity and willingness to use soil fertility and natural resource management options to improve agricultural productivity. At the farmer level, although there are many factors that influence adoption and use of these technologies, studies have shown that rural communities that are characterized by strong social capital have faster rates of technology diffusion and improved environmental management (Claridge 2007, Woolcock and Sweetser 2007). This is because social capital may be the most important resource available for poor communities that are often burdened with low incomes, poor education, and few material and financial assets (Woolcock and Sweetser 2007). Social capital, however, influences the use of technologies differently; for example, technologies that are knowledge intensive may require different forms of social capital than those that are labor or input intensive. Studies on the links between social capital and agricultural technologies

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have, however, not differentiated the different forms of social capital and how these influence the adoption and utilization of different technologies.

TYPES AND MEASUREMENT OF SOCIAL CAPITAL

The term "social capital" has become increasingly popular in different disciplines and an important variable in contributing to rural development. As a result of its popularity and wide application, it has generated different definitions, classifications, and measurement methods (see Bourdieu 1986, Coleman 1988, 1990, Putnam 1993). It is often quoted that social capital is "features of social organization such as networks, high levels of interpersonal trust and norms of mutual aid and reciprocity which act as resources for individuals and facilitate collective action" (Putman 1993, Lochner et al. 1999). Bourdieu (1986) defines it as the "aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition—or in other words to membership in a group—which provides each of its members with the backing of the collectively owned capital." Lochner et al. (1999) adds that social capital has a collective dimension as it is external to the individual and the structure of social capital is hence different from economic capital (money, financial capital) or human capital, e.g., education and training, which are more individual. Benefits of social capital can, however, accrue to the individual as Portes (1998) argues in the definition that social capital is the ability of individuals to secure benefits through membership in networks and other social structures. Social capital captures network-based processes or aspects of social structure that generate communal benefits through norms and trust (Office for National Statistics 2001, Durlauf and Fufchamps 2004). It is the establishment of norms that permit people to work in groups, hence social capital is the consequence of intensely rooted cultural habits (Fukuyama 2004), and as a result, it is defined differently in different cultural settings. The vast literature on social capital further refines its definition to distinguish between bonding, bridging, and linking social capital.

Bonding Social Capital

Bonding social capital is generally defined as closed networks of close friends and relatives or horizontal relationships among equals within a localized community (Claridge 2007, Beugelsdiyk and Smulders 2003). It is the social cohesion that takes place between individuals of similar ethnic backgrounds or social status and it is reinforced by working together (Sanginga et al. 2007a). Szreter and Woolcock (2004) define bonding social capital as the trusting and cooperative relations between members who are similar in a sociodemographic sense. Some examples of this type of social capital include formal and informal clubs, groups, or associations established by farming communities in many villages across SSA. These groups may be formed through church affiliations, local traditional structures, or other localized structures. Bonding social capital is thus characterized by trust and norms that exist within the social structure. Bridging social capital, on the other hand, is widely agreed to be vertical relationships or networks that cross social groupings. These are established between people or organizations that are removed from each other and are in different communities (Claridge 2007, Beugelsdiyk and Smulders 2003).

Bridging Social Capital

Bridging social capital links networks requiring collaboration and coordination with other external groups to achieve set goals; for example, it can be the link between two local groups from different villages. Leonard and Onyx (2003) use five indicators of social capital (networks, reciprocity, trust, shared norms, and social agency) developed by Onyx and Mullen (2000) to define bonding and bridging social capital. The authors define bonding social capital as characterized by dense, multiplex networks, long-term reciprocity, thick trust, shared norms, and less instrumentality, whereas bridging social capital is characterized by large, loose networks, relatively strict reciprocity, and a thinner or different type of trust and more instrumentality.

Linking Social Capital

Linking social capital is the engagement of local groups or networks with institutions or agencies in higher influential positions (Office for National Statistics 2001, Sanginga et al. 2004, Woolcock and

Sweetser 2007). Through linking social capital, groups of poor people are able to access support, resources, and information from organizations and networks. Szreter and Woolcock (2004) define it as the "norms of respect and networks of trusting relationships between people who are interacting across explicit, formal, or institutionalized power or authority gradients in society," such as citizens' interactions with local government.

Woolcok and Narayan (2000) see bonding social capital as operating as a defense mechanism against poverty, whereas bridging social capital is what is required for real economic growth to take place. They see bonding social capital as what communities use to "get by" and bridging social capital as what they use to "get ahead." Leonard and Onyx (2003), however, argue that bridging social capital should not replace bonding social capital as communities have multiple sources of social capital that they draw on for different functions. The three types of social capital, therefore, complement each other, in that the strong bonds existing in bonding social capital are diversified by the existence of bridging social capital, whose bonds are weaker but more cross cutting, hence enabling increased diversity in an otherwise closed community. Linking social capital allows for the accumulation of resources, information, and wealth, which is needed by networks to achieve set objectives. Hence, all three types of social capital can coexist in a community to different extents, but more frequently one maybe more prominent.

With these differences between the three types of social capital, it can be assumed that they have differentiated outcomes, some of which are quantitative in nature. Farmer groups, such as farmer associations or cooperatives, create social relations and enable individuals to achieve goals that they are not able to achieve by themselves. For example, farmers can benefit from economies of scale when sharing transport to access inputs or rely on help in case of sickness or need due to the extended number of friends or people they can trust. More so, frequent interaction will most likely increase the access to information as close friends are likely to share knowledge and information. The functioning of marketing groups is based on the "ability of the group to cooperate on the trust between members" (Lyon 2000). Farmer groups have also been known to enhance the productivity of agri-businesses and are used as a channel for delivering services (Chamala and Shingi 1997). Membership into farmer groups further enables individuals to have access to capacity building efforts such as training and study tours, and to information pertaining to new agricultural technologies. The farmer group or other local-level community formal or informal structures shape norms, such as extent of trust, abiding by bylaws, settling conflicts, cooperation among members, giving gifts, or exchanging items, as well as the extent of financial contributions toward group activities or collective community problems.

Numerous studies have shown that social capital facilitates the diffusion of innovations by increasing the inter-linkages among individuals (Hobbs 2001). And many more studies have been conducted to demonstrate the role of social capital in adoption of various technologies (Chou 2002, Skinner and Staiger 2005, Huijboom 2007). More recently, a number of studies have specifically looked at the role of social capital in the adoption of improved agricultural technologies, such as the adoption of improved inputs, soil and water conservation technologies, agro-forestry technologies, and improved crop management (Parthasarathy and Chopde 2000, Isham 2002, Sanginga et al. 2004, 2007a, b). All these studies concur that social capital has a positive impact on the adoption and use of improved agricultural technologies. Most of these studies linking social capital to technology use and adoption have mainly used qualitative measures of social capital, such as membership in groups or associations. Few studies have attempted to isolate the different types and aspects of social capital from a quantitative perspective.

This paper looks at the empirical measurement of social capital, uses this to differentiate the different forms of social capital, and analyzes how these different forms influence the adoption and use of soil management technologies. The paper uses factor analysis to group social capital variables into three categories, thus providing an empirical analysis of the links between different types of social capital and technology use. This paper postulates that different types of social capital facilitate—to different extents—networking among rural households, which results in accumulation of knowledge and in adoption of improved soil management options. The paper contributes to the current debates in social capital by providing an empirical, quantitative method for the measurement of the different forms of social capital and the relationships that these have with the use of improved technologies by smallholder farmers.

METHODOLOGY

Study Location and Sampling

The study was carried out in the Chinyanja Triangle, which is composed of the Eastern Province of Zambia, Southern and Central Regions of Malawi, and Tete Province of Mozambique, where the predominant language is Chinyanja. In this area, agriculture is the most predominant source of livelihood (Myburgh and Brown 2006). The area is not easily accessible and agricultural inputs are transported over long distances, making them costly and unaffordable for most smallholder farmers. Population is very dense and the land-holding size for most households is less than 1 ha (Ajayi et al. 2003, Myburgh et al. 2006).

A four-stage cluster sampling technique was used to select a total of 630 farming households from Malawi, Zambia, and Mozambique. In the first stage of clustering, the three countries were purposefully selected from Southern Africa based on the criteria that they share geographical boundaries and the Nyanja language and form the Chinyanja Triangle area. In the second stage of sampling, five sites were purposefully selected from each of five districts across the three countries. Two districts were selected from Malawi (Lilongwe and Kasungu), two from Mozambique (Tsangano and Angonia), and one from Zambia (Chipata District). The districts were selected purposefully based on the criteria that several research and extension institutions are working in those districts to promote soil fertility management technologies, including the appropriate use of organic and inorganic fertilizers. In the third stage of sampling, eight communities or villages were purposefully selected to target areas working within a USAID-funded Livelihoods Improvement Program within the Chinyanja Triangle. The fourth stage involved random selection of 630 households from within the group villages.

A semi-structured questionnaire was used to collect information on key variables of social and human capital, knowledge and use of improved soil management options, information pertaining to crop and livestock production, income-generating activities, markets and agro-enterprises, food security and dietary diversification, fertilizer use, as well as gender relations. For social capital variables, respondents were asked a set of questions relating to households relationships with others in and outside their communities.

Data Analysis

Factor analysis is used in this paper to identify the concealed types of social capital that exist and that are manifested in features of social organizations. The different types of social capital are both observable and unobservable variables as they result from complex social interactions, such as trust, norms, and shared values, whose tangibility can be measured through individual member perceptions (Durlauf and Fufchamps 2004). Factor analysis can concurrently manage large sets of variables with unknown interdependencies by using correlations to group sets of variables (Rummel 2007), where each group represents a single hidden factor. The social capital variables in this study were analyzed using the Principal Axis Factoring Method with Varimax rotation. By default, only factors with eigenvalues greater than one are retained in the analysis; for this study, however, only factors whose eigenvalues were greater than 1.3 were retained, as this entails that the factor is accounting for a greater proportion of the variance than the original variable and hence it facilitates better interpretation. Additionally, only variables with factor loadings greater than 0.3 were used for the factor analysis. Using factor score regression, a new data set representing each household sampled was generated and this was used to incorporate social capital as a variable in the development of a logit model to analyze the relationship between the social capital factors existing and the use of improved agricultural technologies. Onyx and Mullen (2000) have similarly used factor analysis to group social capital variables.

Choices between different strategies are commonly modeled using binary models like probit and logit. Logit regression was used to analyze the determinants of farmers' use of certain technologies. Several studies have used the logit model in relation to adoption of different technologies (Mariam et al. 1993, Buckles et al. 1998, Zegeye et al. 2001, De Groote et al. 2002, Cramb 2004, Nyende and Delve 2004). The estimated regression model predicts the probability that the dependent variable takes a value of 1.

$$\text{Logit}(p_i) = \ln (p_i/1 - p_i) = \beta_1 x_{1,i} + ... + \beta_k x_{k,i}$$

The unknown parameters β_j are usually estimated by likelihood. The interpretation of the β_j parameter estimates is as the additive effect on the log odds ratio for a unit change in the *j*th explanatory variable.

The three social capital variables extracted in the factor analysis are included as variables in the logit model using the factor scores that were generated.

RESULTS AND DISCUSSION

Principal Factor Analysis

From the analysis of social capital variables used in the Factor Analysis, three underlying factors of social capital emerged (Table 1). Factor 1 can be termed "Bonding Social Capital." This is because different variables that facilitate creation of cohesion among people in a community have high positive loadings. This includes cooperation among people (0.848), extent of trust among people (0.784), and participation in community activities (0.654). Other signs of solidarity, such as the extent of settling conflicts and extent of abiding by norms, also have factor loadings that can be considered to be on the greater side (greater than 0.3). The extremely high positive loading on cooperation, implies that creation of trust, settling of conflicts, participation in community activities, and abiding by norms are all enabled by an environment where there is high cooperation between and among the people. These findings concur with studies by Bowles and Gintis (2002, as quoted by Durlauf and Fufchamps 2004) that found that bonding social capital generally refers to trust and a willingness to live by norms and bylaws of one's community.

Bonding social capital as seen from the factor loadings is a characteristic of within-group relations, the extent to which people within the same group or community cooperate with each other, participate in joint activities, and the extent to which they trust one another. Pretty et al. (2005) defines bonding social capital as the connectedness that exists between individuals within local groups and communities or what they refer to as local connections. It is the links between people that have similar outlooks and objectives. These connections may take many forms, such as exchange of information, exchange of gifts and reciprocity, helping each other out, working collectively toward a common goal among other things. Bonding social capital is linked to high levels of trust, reciprocity, and community action. These characteristics of bonding social capital are expected to be positively linked to adoption and use of technologies that require collective action, such as soil erosion control, pest and disease management, and management. The bonding social capital is also expected to have a positive relationship with technologies that require pooling of labor due to their labor-intensive nature. Some groups in Kenya, for example, were formed for the purpose of pooling and sharing labor across households especially for soil and water conservation.

The second factor of social capital that has emerged with high positive loadings can be associated with bridging and linking social capital. Variables loading onto this factor include membership in groups outside of one's community, extent of financial contributions for group and wider collective activities, and links with extension staff and access to training by other organizations. All these variables have aspects of links or networking across groups and with outside organizations. The bridging and linking social capital implies links across groups, across communities, and with other organizations. These two types of social capital are expected to have a positive relationship with knowledge-intensive technologies that require sharing of information on their use, training, or visiting other farmers, research institutions, and other organizations where these technologies are developed or demonstrated. It is not surprising that group formation and the presence of extension have loaded highly on the same factor as empirical evidence has shown that one of the key roles of extension service providers is to help farmers or community members empower themselves to form groups that are organized for development.

The third factor that does not seem to fit within any of the existing social capital classifications in the literature is related to gender relations at the community level, as indicated by high positive loadings on women's ability to speak with confidence in pubic and men's respect and consideration of ideas given by women. These two factors represent women's empowerment and improved gender relations at the community level, and this could be enhanced due to the high levels of cohesion that exist within the communities as explained by factor 1. The higher loading on men's respect and consideration for women's ideas indicates empowerment of women and men's acceptance of women as partners in development. We have called this factor "gendered social capital" and it is expected to have a positive relationship with technologies that favor women, whether in terms of reducing their labor or increasing their cash returns.

Table 1. Principal factor analysis of social capital variables

Social Capital Variables[1]	Underlying factors (Unobservable)		
	Factor 1: Bonding	Factor 2: Gender	Factor 3: Bridging and Linking
Training or participation in study tours	-	-	-0.334
Membership in a farmer group	-	-	0.690
Membership in more than one farmer group	-	-	0.462
Participation in community activities	0.654	-	-
Extent of trust among people	0.784	-	-
Cooperation among people	0.848	-	-
Extent of giving or exchanging gifts	-	-	-
Extent of financial contribution for community activities	-	-	-
Extent of financial contributions for farmer group activities	-	-	-0.508
Spirit of helping others, especially the poor	-	-	-
Extent of settling of conflicts	0.434	0.399	-
Extent of abiding by the norms and bylaws	0.397	0.475	-
Women having confidence to speak in public		0.670	-
Men's respect for and consideration of ideas given by women	-	0.787	-
Presence of extension worker in community	-	-	0.412

Kaiser-Meyer-Olkin (KMO) measure = 0.753

[1] These are features of social organization that are observable.

Technology Use

Several soil management options were considered. The technologies, their characteristics, and uses are summarized in Table 2.

From Table 3 it can be seen that different types of technologies are widely used in different combinations across the three countries. Two of the most commonly used technologies in Malawi besides inorganic fertilizer were early ploughing (49%) and incorporation of crop residues (47%). In Zambia, the most commonly used technologies were crop rotation (86%) and the use of animal manure (47%). Incorporation of crop residue was used by 85% of the farmers in Mozambique, whereas early ploughing was used by 47%. Across the three countries, crop rotation was the most commonly used technology, with 57% of farmers using it, followed by incorporation of crop residue and early ploughing. The use of botanicals was not common, and was used by less than 10 of the 630 farmers interviewed.

Table 2. Soil management options, their characteristics and uses

Soil management options	Short description
Crop Rotation	Production system where different crops are grown in sequence to avoid continuous cultivation of the same crop, on the same land, year after year
Incorporation of crop residue	Process of adding crop residues to the soil, either through ploughing in, or by mulching and allowing macro-fauna to incorporate residues with time
Animal manure	Collection, management, and use of animal manure for increasing nutrient and organic matter additions to the soil
Agroforestry trees	Planting of tree species either as a rotation, a fallow, or on field/farm boundaries
Resting land fallow	Removal of land from crop production for a number of seasons to allow the soil fertility to replenish
Soil erosion control	Process of active control of water movement across the soil surface, either by terracing, using trash lines, or fanya juu, fanya chini
Early ploughing	Early land preparation to allow more timely seed sowing and for improved weed control
Cover crops	Use of certain species, mostly nitrogen fixing, as a sole or relay crop, to provide ground cover during the dry season, provide biomass of soil fertility improvement, conserve soil moisture, and provide dry season livestock feed
Botanicals for pest and disease management	Use of local species like Tithonia, chili, marigold to prepare a water-based pesticide

Relationship between Social Capital and Technology Use

Adam and Roncevic (2003) make several conceptualizations of social capital, one of which is social capital as catalyst for disseminating human and intellectual capital. They postulate that economic capital on its own is not sufficient to achieve certain development goals and that social capital is required as an asset that can facilitate the circulation, recombination, and reconfiguration of human capital in order to make it useful for technological application and for the solution of both social and economic problems. The authors see a slow link between social capital and the application of human and technological knowledge.

The factors influencing use of the technologies varied widely and these are presented in the results of the logit model (Table 4). Bridging and linking social capital significantly influenced the use of crop rotation, crop residues, planting of agroforestry trees and the use of inorganic fertilizers. Gender was more linked to soil erosion structures, planting of agroforestry trees, use of cover crops, and fallows. Crop residue incorporation increases the organic matter content of soil and hence soil fertility. The type of residue, time of incorporation, and role in organic matter in crop production is a knowledge-intensive process, and this knowledge is acquired through technology messages, on-farm demonstrations, and field visits to other farmers using these technologies. This is unlike other less knowledge-intensive technologies, e.g., inorganic fertilizers. Results show that farmers with more linking and bridging social capital use these technologies more than farmers who have fewer links (Table 4). Kiptot et al. (2006) found that although informal and kinship networks were useful for the dissemination of seed, they were not commonly used for dissemination of knowledge and knowledge-intensive technologies.

Although social capital increases farmer's adoption of soil conservation measures (Cramb 2004), the results show that it has a significant negative

Table 3. Use of soil management technologies across the Chinyanja Triangle

Technology	Percentage of farmers using technology Malawi	Zambia	Mozambique	Total	Chi-square value
Crop rotation	52.1	85.9	39.4	56.6	66.674***
Incorporation of crop residue	46.5	34.1	85.4	52.3	82.972***
Animal manure	27.7	47.4	43.8	35.5	21.900***
Agroforestry trees	20.2	26.7	26.3	22.9	3.48
Resting land fallow	16.8	31.9	18.2	20.3	14.157***
Farmyard manure	38.2	18.5	20.4	30.1	25.795***
Soil erosion control	27.2	26.7	39.0	29.7	7.223**
Early ploughing	49.0	24.4	47.4	43.4	25.249
Cover crops	16.9	3.7	13.2	13.3	14.813***
Botanicals for pest and disease management	1.7	0.0	0.0	1.0	4.615**

relationship with crop rotation, planting of agroforestry trees, and use of inorganic fertilizers (Table 4). One reason is that it is smallholders with larger land sizes and access to capital that most often use crop rotations and purchase inorganic fertilizers and these smallholders are the least likely to depend on social networks for support compared with poorer households with smaller land holdings. A Pearson test showed a negative significant correlation (at $p = 0.01$) between the bonding and linking social capital and land size indicating the greater the land size, the lower the farmers' bonding and social capital.

Bonding social capital was found to be positively significant in influencing the use of cover crops. This implies that stronger bonds or cohesion within a community will lead to more members growing cover crops. This can be attributed to that for many rural communities with low access to improved technologies; access to seeds for many crops, including cover crops, is through informal networks and interactions (Winters et al. 2006) and within a village of clansmen, the seeds are shared and this positively influences their use. A study in Kenya (Kiptot et al. 2006) found that most seed dissemination of agroforestry trees and shrubs were along kinship ties rather than formal systems of seed distribution. It is, however, not surprising that the existence of bonding social capital was only significant in influencing the adoption of one type of improved technology. Other studies conducted by Winters et al. (2006) similarly found that households with strong bonding social capital are less likely to be diversified in their adoption and use of improved innovations.

Gender was expected to have a positive relationship with technologies that were in favor of women, either in terms of increasing their incomes, improving their access to resources or reducing their labor. This category of technologies included agroforestry trees and legume cover crops. In this analysis, gender social capital was found to have a positive and significant relationship with agroforestry trees, which may be attributed to the fact that the use of agroforestry trees increases access by women to firewood sources, fodder for

Table 4. Factors influencing use of different soil management technologies in the Chinyanja Triangle

Variable	Coefficient	Std. error	*p* value
Soil Erosion structures			
Constant	-1.561	0.518	0.003**
Sex of household head	0.761	0.281	0.007**
Perception of poverty	-0.114	0.232	0.625
Perception of fertilizers	-0.393	0.208	0.059*
Perception of soil fertility	-0.497	0.160	0.002**
Hiring of labor	-0.078	0.222	0.722
Land area in ha	0.356	0.083	0.000***
Bonding	-0.289	0.113	0.798
Bridging and linking	0.0139	0.126	0.913
Gender	0.254	0.122	0.038*
Age of household head	0.007	0.006	0.260
Household income	0.004	0.003	0.109
Crop rotation			
Constant	-0.037	0.488	0.939
Sex of household head	-0.049	0.244	0.984
Perception of poverty	0.058	0.225	0.794
Perception of fertilizers	-0.516	0.209	0.014*
Perception of soil fertility	-0.155	0.149	0.299
Hiring of labor	0.638	0.219	0.004**
Land area in ha	0.616	0.116	0.000***
Bonding	-0.173	0.109	0.113
Bridging and linking	-0.366	0.123	0.003**
Gender	-0.627	0.111	0.575
Age of household head	0.006	0.006	0.302
Household income	-0.001	0.002	0.580
Incorporation of crop residue			

(con'd)

Constant	-1.281	0.469	0.006**
Sex of household head	0.271	0.231	0.241
Perception of poverty	-0.011	0.218	0.960
Perception of fertilizers	-0.102	0.197	0.604
Perception of soil fertility	0.903	0.141	0.524
Hiring of labor	-0.377	0.207	0.069*
Land area in ha	0.076	0.061	0.211
Bonding	0.072	0.102	0.482
Bridging and linking	0.261	0.120	0.030*
Gender	0.025	0.106	0.811
Age of household head	-0.002	0.006	0.726
Household income	0.001	0.003	0.004**
Agroforestry trees			
Constant	-1.704	0.557	0.002**
Sex of household head	-0.182	0.269	0.499
Perception of poverty	-0.164	0.244	0.501
Perception of fertilizers	-0.679	0.217	0.002**
Perception of soil fertility	-0.007	0.165	0.962
Hiring of labor	0.340	0.227	0.135
Land area in ha	0.091	0.659	0.169
Bonding	-0.090	0.118	0.447
Bridging and linking	-0.562	0.140	0.000***
Gender	0.308	0.136	0.024*
Age of household head	0.014	0.007	0.047*
Household income	0.002	0.002	0.368
Cover crops			
Constant	-0.830	0.746	0.266
Sex of household head	0.554	0.437	0.205
Perception of poverty	0.602	0.315	0.849

(con'd)

Perception of fertilizers	-1.018	0.276	0.000***
Perception of soil fertility	-0.460	0.220	0.036*
Hiring of labor	0.227	0.298	0.446
Land area in ha	0.104	0.072	0.150
Bonding	0.787	0.224	0.000***
Bridging and linking	-0.168	0.171	0.324
Gender	0.680	0.209	0.001**
Age of household head	-0.006	0.009	0.539
Household income	-0.003	0.005	0.557
Fallows			
Constant	-2.793	0.618	0.000***
Sex of household head	0.808	0.326	0.013*
Perception of poverty	-0.660	0.281	0.019*
Perception of fertilizers	-0.999	0.233	0.000***
Perception of soil fertility	-0.173	0.182	0.339
Hiring of labor	0.251	0.246	0.307
Land area in ha	0.296	0.085	0.001**
Bonding	-0.151	0.124	0.222
Bridging and linking	-0.079	0.149	0.593
Gender	-0.270	0.129	0.037*
Age of household head	0.023	0.007	0.003**
Household income	0.001	0.002	0.550
Inorganic Fertilizer			
Constant	2.596	0.566	0.000***
Sex of household head	-0.694	0.287	0.016*
Perception of poverty	0.447	0.275	0.104
Perception of fertilizers	-0.348	0.239	0.147
Perception of soil fertility	-0.076	0.166	0.649
Hiring of labor	0.938	0.267	0.000***

(con'd)

Land area in ha	0.191	0.114	0.094*
Bonding	0.135	0.118	0.253
Bridging and linking	-0.444	0.144	0.002**
Gender	-0.112	0.126	0.374
Age of household head	-0.004	0.007	0.543
Household income	0.001	0.006	0.039*

livestock, and fruit trees. Although the study did not distinguish what kind of agroforestry trees were being planted by households, it can be assumed that some of these trees have uses of benefit to women. Cover crops as expected were also found to have a significant relationship with the gender variable. Cover crops are mainly legumes, such as soya beans, lablab, and groundnuts. For women, legumes offer a more attractive source of household income than traditional cash crops in southern Africa, such as tobacco, cotton, and maize as these are often controlled by men. The positive significant relationship between soil erosion control and gender was unexpected. It had been hypothesized that due to the high labor requirement of constructing and maintaining soil erosion control structures, that the relationship between the gender variable and soil erosion structures would be negative. However, one of the most common form's of soil erosion control in Malawi is the planting of vetiver grass. Apart from being an effective mechanism for the control of erosion, the grass also provides fodder within the confines of their own farms for livestock, thereby reducing women's time and labor for harvesting fodder in communal areas. Additionally, the positive relationship also means that, as women are empowered, they are better able to find means of ensuring that labor-intensive technologies that normally elude them, are incorporated into their farmsteads. The negative significant relationship between gendered social capital and fallowing of land is not unexpected. Literature shows that land owned and managed by women is often under utilized due to lack of sufficient labor, information, education, and resources (Food and Agriculture Organization (FAO) 1995, Pinkard 2006).

Other Determinants of Technology Use

From the analysis, the sex of the household head was found to have a positive and significant relationship with soil erosion control and fallows, and a negative relationship with inorganic fertilizers. This implies that households that were headed by men were more likely to use soil erosion structures and fallows than households headed by women. The effects of the sex of the head of household, however, has more to do with the unequal access to resources by women, which is common in most African countries. Women have been found to have less access and control of resources, such as land and property, and less access to services such as agricultural credit and information (Quisumbing et al. 1995, Njuki 2001).

Various studies have looked at the role of land size in determining the use of soil and water management technologies (Isham 2002, Kaliba et al. 2000, Marenya and Barrett 2007, Waithaka et al. 2007). The probability of using fertilizer, fallows, crop rotation, and soil erosion control was positive and significant. Although some of the technologies, such as fallows, are land and scale dependent and not appropriate for households with small land sizes, for others the effects may be due to other factors that are related to land. These may include the fact that wealthier households have bigger farm sizes and are also able to purchase fertilizers, and they have a broader crop mix and therefore use crop rotations. A study by Marenya and Barrett (2007) found significant relationships between farm size and the use of stover lines, agroforestry, manure, and inorganic fertilizers in Western Kenya. Older heads of households were more likely to use agroforestry trees and fallows. This is due to the larger land sizes associated with older people. In the customary land-tenure system common in the three countries, land is distributed by traditional chiefs. Young people, when they marry, then receive land from the chief or from their parents. Due to this age-dependent system, younger people tend to have smaller land sizes than older people.

One of the commonly neglected factors in assessing the use of technologies by smallholder farmers is the role of farmers' own perceptions of both the technologies and the status of their soils. Farmers' perceptions were found to play an important role in determining the use of technologies. Farmers who perceived fertilizers to be bad for the soil were more likely to use other soil management options. There was a negative correlation between the perception of fertilizers as good for the soil and the use of most of the technologies, including crop rotation, agroforestry trees, cover crops, and fallows. Farmers who perceived their soils to be fertile were also less likely to use soil management options and soil erosion control strategies. This was especially significant for the use of cover crops, and soil erosion management. Although farmers' perceptions of different technologies have been sought, studied, and documented, they have rarely been used ito model the determinants of technology use.

CONCLUSIONS AND RECOMMENDATIONS

The results of this study show that the use of various soil management technologies depends on socioeconomic variables and the existence of different dimensions of social capital. Social capital is especially important in determining whether households have access to, and therefore use, different soil management technologies. Although different studies have looked at social capital in terms of membership in groups, this study shows the need to differentiate different kinds of social capital as these influence technology adoption differently. There is, therefore, a need to develop multiple indicators for measuring the different forms of social capital and how these forms influence research and development outcomes. The study finds that bonding, bridging, and linking social capital all influence the adoption and use of different soil fertility management options, a trend that might be similar for other agricultural technologies as well. The study recommends investments especially by development organizations in strengthening these different forms of social capital by supporting local kinship or community groups that generate social capital, promoting farmer access and links with external organizations that can act as sources of information and technologies for farmers, as well as links with other farmer associations and groupings from whom they can learn.

Gendered social capital was found to be a critical factor in improving the adoption and use of technologies that are especially beneficial for livelihood outcomes. Extension and community development programs, therefore, need to deliberately incorporate gender within extension and other programs aimed at increasing access to technologies; they need to promote technologies that are beneficial to women in terms of increasing their incomes or reducing their labor. Efforts to promote the empowerment of women, increase their voice, and improve household gender relations are crucial. Lastly, in order to broaden the knowledge base and adoption of improved technologies, it is essential that the entry point for working with communities ensures that there are links between these communities and other groups of farmers in order to broaden the scope for networking beyond local community and kinship groupings.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/vol13/iss2/art9/responses/

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