

*Full Length Research Paper*

# Socio-economic factors critical for adoption of fish farming technology: The case of selected villages in Eastern Tanzania

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Improving farm production through integrating modern technologies into the existing farming system is essential for the enhancement of household food and income security. Fish farming is one of the technologies that were introduced to meet that end. A study was conducted to identify factors that influence the adoption of fish farming technology. Data were collected from 340 respondents randomly sampled from selected villages in Eastern Tanzania and was analyzed using the probit model. Results indicate that sex, age, formal education, religious beliefs, extension education, land size, income, family size, risk and profitability are important for the adoption of fish farming technology. Three recommendations emerge from these findings. First, planners and extensionists should target fish farming technology to farmers with resources necessary to adopt the technology and those who do not have religious belief that impede the practice of the technology. Second, there is need to provide extension education for potential farmers on various aspects of fish farming as this will stimulate the up-take of the technology. Finally, technology developers should strive to improve the profitability of fish farming through the reduction of the risk of losing fish, shortening culture cycle to target market size fish, use of low cost inputs and/or integrating fish farming with the existing farming systems and access to urban markets.

**Key words:** Adoption, fish farming, household resources, Tanzania.

## INTRODUCTION

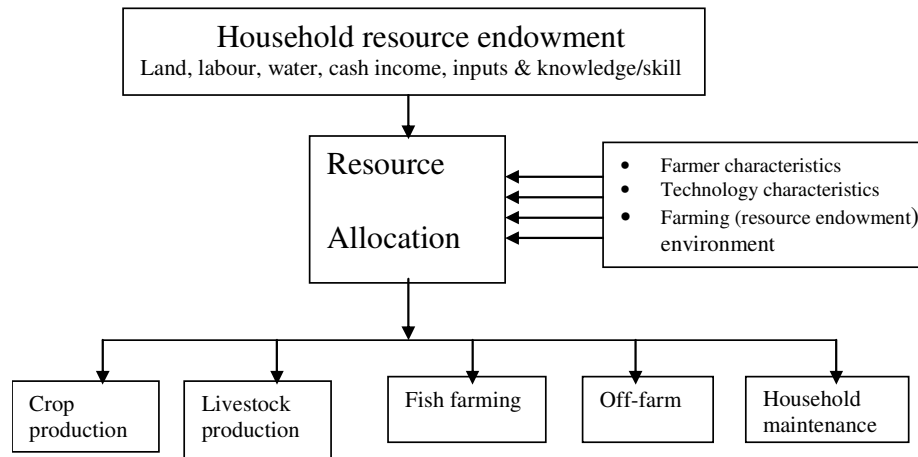
A background study conducted in the selected villages of Morogoro and Dar es Salaam Regions, Tanzania, revealed that most people are unable to produce enough food and income to satisfy household needs (ALCOM, 1994). The study further revealed that there is poor nutritional content of food produced; most household diet comprising of cereal crops (ALCOM, 1994). Women and children are most affected by this poor nutritional content as they have little access to proteins. Participants in Participatory Rural Appraisal (PRA) conducted by this study revealed that some men eat roast meat (*nyama choma*) outside their homes when drinking local beer. Inadequate food security and poor nutritional diets lead to disease, sickness and famine that directly contribute to reduction in labour productivity (ALCOM, 1994). The introduction of technologies that will improve nutrition, food and income are seen as critical to the future development of the area.

Fish farming is one of the technologies that were intro-

duced in the area to meet that end (Wetengere et al., 1998). Fish, when available, are generally cheaper than land animal meat and contain protein levels of 17-20% as well as minerals and vitamins (Hague, 1992). They are also low in fat and high in polyunsaturates, that can help to reduce the levels of cholesterol in the blood (Hague, 1992).

ALCOM progress reports revealed that fish farming supplies cheap and readily available fish for home consumption and sale, increased production of crops like vegetables, bananas, yams and sugarcane and the crops were grown all the year-round as a result of benefiting directly from fertilized pond water and/or moisture. In Malawi, fish farming integrated into an existing agricultural system increased production, overall farm productivity and produced up to a six-fold improvement in profitability (Brummett and Noble, 1995).

Despite high potential that integrated fish farming has in optimizing rural development, there are mixed feelings



**Figure 1.** A farmer's decision to adopt fish farming technology.

among farmers on adoption of the technology (Wetengere, 2008). The adoption rates measured as the percentage of potential farmers with suitable resources has been very low (Wetengere, 2008). The low adoption rates imply that farmers attach a relatively low importance to fish farming which reflects the high opportunity cost to adopt the technology (Wetengere, 2008).

Studies by Polson and Spencer (1991), Minde and Mbiha (1993), Mattee (1994), Mlozi (1997), Senkondo et al. (1998) and Batz et al. (1999) on technology adoption concentrates on factors that influence adoption of modern technology in relation to traditional technology. Furthermore, there is hardly any detailed and systematic study on diffusion of fish farming technology. If, for instance, factors influencing adoption of coarse grain or stall-feeding of dairy cattle or improved cassava technologies were to be employed in the adoption process of fish farming, there is no guarantee that it would work with the same degree of success because the technologies are different.

In contrast, this study realizes that adoption of a new technology is not only a choice between two alternatives: the traditional and modern technology (Kisusu, 2003); it is also a choice of one technology against other technologies, particularly if they serve the same purpose or compete for the same resources (Wetengere, 2008). In such a situation a farmer compares fish farming with other options before an adoption decision is made. Understanding factors that influence adoption of fish farming technology has attracted the attention of researchers. The objective of this paper therefore is to examine factors which influence adoption of such technology.

### Theoretical framework of adoption choice

When fish farming technology is introduced in a given vil-

lage or a farmer hears about fish farming or sees a pond, he or she is confronted with a choice of whether to adopt it or not. A typical small-scale farmer is never a specialist, but he produces different crops and vegetables, rears livestock in combination (FAO, 2000) and carries other off-farm activities. Household resources are allocated over these activities on the basis of resource endowment, and farmer and technology characteristics (Figure 1). The allocation decision as explained in Temu (1999) is often characterized as a 2-stage process in which first priority is given to meeting food security requirements. The second objective is then to maximize income using the remaining resources (Temu, 1999). In such a situation a balanced model using both on-farm and off-farm for aquaculture may be needed for improved household welfare (Edwards and Demaine, 1997).

For the purpose of this study it is assumed that farmers make adoption decisions on the basis of utility considerations (Batz et al., 1999). Comparing various technologies that are utilised, farmers will adopt a technology if its utility exceeds that of other activities. The probability that a farmer adopts a technology is a function of its relative utility (Batz et al., 1999). Utility of an activity is measured by its contribution to household food and income security.

This problem was addressed using the probit model as follows;

$$y_i = \beta_0 + \beta_1 X + \beta_2 Z + \beta_3 U + \varepsilon_i;$$

Where;  $y_i$  is the probability that the  $i$ th farmer will adopt fish farming or not,  $\beta$  are parameters,  $X$  is farmer characteristics,  $Z$  is technology characteristics and  $U$  is resource endowment factors and  $\varepsilon$  is an error term which represents unobservable factors assumed to be independently distributed over the survey period. Since variable  $y$  can take on only one of two values: 1 or 0 (adopt or

not adopt), a binary choice model is used to analyze this adoption decision.

First, the expected utility from adopting fish farming or not given the influencing factors will be determined:

$$Eu_{iff} (\text{adopt fish farming}) = f(\text{influencing factors}) + \epsilon_i$$

$$Eu_{io} (\text{not adopting fish farming}) = f(\text{influencing factors}) + \epsilon_i$$

Where;

$Eu_{iff}$  = Expected utility of the  $i$ th household from adopting fish farming technology.

$Eu_{io}$  = Expected utility of the  $i$ th household from not adopting fish farming or adopting other technology.

$\epsilon_i$  = Error term.

Second, the expected utility from fish farming will be compared with that of other technologies such that:

$$\frac{Eu_{iff}}{Eu_{io}} > 0 \text{ or } \frac{Eu_{iff}}{Eu_{io}} < 0$$

Third, using  $y_i$  as an indicator of whether the  $i$ th household adopts fish farming technology ( $y_i=1$ ) or not ( $y_i=0$ ), then:

$$y_i=1 \text{ if } \frac{Eu_{iff}}{Eu_{io}} > 0 \text{ and } y_i=0 \text{ if } \frac{Eu_{iff}}{Eu_{io}} < 0$$

Therefore, the probability that the  $i$ th household adopts fish farming technology is the probability that the expected utility gained from the adoption of fish farming technology is greater than the expected utility derived from other technologies or not adopting fish farming.

## METHODOLOGY

The data reported here were collected to identify socio-economic factors critical to adoption of fish farming technology. This study was conducted from November 2005 to May 2006 in selected villages of Morogoro and Dar es Salaam Regions, Tanzania. Given the nature and complexity of this problem, a field survey design that focuses on the individual farmers as the unit of analysis was employed. This method is capable of describing the existing perception, attitude, behaviour or values of individuals within a household (Mugenda and Mugenda, 1999).

The sampled population in each village was stratified into two categories, fish adopters - those who adopted and continue to practice fish farming and non-adopters - those who have never adopted fish farming. From each village list, a systematic random sampling approach was used to select the respondents. This sampling technique was used to avoid conscious or unconscious bias in the selection of sampled households and ensured that the selected sample was representative of the population. In total 340 farmers were selected of which 234 (69%) were fish adopters and 106 (31%) non-adopters. A large sample was required to produce salient characteristics of the population to an acceptable degree and also reduce sampling errors (Mugenda and Mugenda, 1999).

The instruments used for data collection were questionnaire, Participatory Rural Appraisal (PRA), personal observations and secondary information sources. A structured questionnaire was prepared

and given to aquaculture experts to check content and validity. After incorporating experts' comments, it was pre-tested, and then a final version incorporating the pre-test results was produced. All questionnaires were administered through face-to-face interviews by the author and an assistant researcher. In each village a PRA meeting was conducted covering various topics such as ranking of different technology characteristics and why farmers are doing what they are doing.

Data analysis was conducted with Stata 8 and the Statistical Package for Social Sciences (SPSS) computer programmes. Only significant variables were considered to have influence the adoption of fish farming technology. In analyzing technology characteristics the scoring approach was used to assess all activities carried out by farmers. The scoring approach was chosen because a quantitative assessment for each technology would have involved a high cost and needed much time. The same approach was used by Batz et al. (1999) and Polson and Spencer (1991). Farmers' assessment was scored on a scale of 1-7 depending on the number of activities carried out by the farmer. Score 1 meant best and 7 worst. For instance, in assessing the relative profitability of vegetable gardening and fish farming, a score of 1 for vegetables and 2 for fish farming indicated that vegetable gardening was more profitable than fish farming. Unlike Batz et al. (1999) who used extension officers to represent farmer's perception on adoption, this study used the perception of the farmers themselves. This process ensured that the views of the farmer, the ultimate user and beneficiary of the technology, were considered in the evaluation process.

## Adoption determinants

Factors which influence the adoption of fish farming technology were identified through literature review and practical experience while working with fish farming projects.

## Farmer characteristics

- i) Education: An educated farmer is more likely to adopt new technology than an uneducated one (Meena et al., 2002).
- ii) Age: Young and middle-aged farmers are aggressive and energetic people who are more willing to adopt new technology than older farmers. Older farmers are conservative, risk-averse and unlikely to try new ideas.
- iii) Gender: Females are less likely to adopt fish farming than males due to: their high workload, they do not own land, are not decision makers, a lot of physical labour is required in pond digging (Edwards and Demaine, 1997), it involves major repairs, and their state of poverty.
- iv) Belief: Some religious beliefs prohibit the consumption of certain fish species and using pig manure and brew leftovers for fertilization and feeding fish, respectively. Farmers with such beliefs are unlikely to adopt fish farming technology.
- v) Income: The adoption of fish farming is financially demanding, fish farmers rich in terms of income are more likely to adopt fish farming than poor farmers. On the other hand, if the expected contribution of income from fish farming is higher than that from other activities, farmers are more likely to allocate income to fish farming.
- vi) Knowledge and skills: Farmers who have acquired knowledge on fish farming are more likely to adopt it than those who have not acquired the knowledge.

## Technology characteristics

- i) Profitability: For the purpose of this study, 'profit' is defined as the

difference between total revenue received and the total cost of inputs. Farmers are more likely to adopt fish farming technology if the technology promises higher returns to investment than other farm technologies and vice versa.

ii) Marketability is defined as the ease with which a product can be sold relative to other, competing products. Farmers are more likely to adopt fish farming if farmed fish is more marketable than other competing products and vice versa.

iii) Risk is defined as a situation in which the probability of obtaining some outcome of an event is not precisely known (Todaro, 1982). Farmers will be interested in adopting technologies that reduce risk in their farming operations and vice versa.

iv) Immediacy of reward is defined as the speed with which a farmer receives income or fish for home consumption after starting fish farming and afterwards. If fish farming rewards faster than other competing activities it is more likely to be adopted. Resource-poor farmers cannot afford to wait for too long to earn a return on their investments.

v) Complexity can be defined as the number of activities that have to be performed to adopt and use the technology relative to other technologies (Batz et al., 1999). If adoption of fish farming requires the adoption of a number of activities than other farm technologies do, it is less likely to be adopted and vice versa.

vi) Operational costs are defined as day-to-day costs of keeping the activity running. If the costs of running fish farming are lower than other competing activities, fish farming will likely be adopted and vice versa.

vii) Status is defined as the relative social position that fish farming as an activity or fish as a relish is assigned by participating farmers. If fish farming and fish are assigned high status compared to other competing activities or sources of relish, fish farming is more likely to be adopted and vice versa.

viii) Palatability can be defined as the preference for fish in terms of taste. If demand changes in favour of farmed fish, fish farming is likely to be adopted and vice versa.

ix) Easy availability to obtain farmed fish can be defined as the ease with which farmed fish can be obtained from the pond for consumption and for sale. The easy availability of farmed fish is dependent on harvest methods in practice. If the harvest method allows farmed fish to be obtained more easily than other competing relishes particularly during animal protein shortage, fish farming is more likely to be adopted and vice versa.

x) Frequency of consumption can be defined as the number of times farmed fish is consumed in a given period relative to other competing relishes. The frequency with which fish is consumed depends on the management, availability of fish in the pond, palatability, easy availability, status, lower price, preparation and preservation advantages. If farmed fish can be consumed regularly relative to other competing relishes of animal meat, fish farming is more likely to be adopted and vice versa.

### Farming (resource base) environment

Certain amounts of inputs are required to be able to adopt fish farming (Figure 1). When the above inputs are forthcoming from the farming environment - that is, they are readily available and do not have alternative uses, farmers are more likely to adopt fish farming and vice versa.

### Descriptive statistics of the study area

Table 1 presents the demographic characteristics of 340 respondents sampled from Morogoro and Dar es Salaam Regions. Male respondents comprised of 75% with more or less equal proportions in the two Regions. About 78% of the respondents were heads of households a fact which ensured that detailed household informa-

tion sought was obtained easily. About 83% of the respondents were married, 11% were single and 6% others (widowed, divorced or separated).

As expected, 99% of the households do farming as one of their livelihood earning activities. However, 45% of the respondents indicated that farming was the household's main activity. About 50% of the respondents derived their livelihood from farming and business, 3% derived their livelihoods through farming and employment and others [that is, farming and business, student and employment] (2%). The data indicates that 47% of full time farmers and 51% of those who combine farming with business came from Morogoro, 33% of those who combined farming with other employment and 15% of the others [that is, farming with business and employee only] came from Dar es Salaam.

The percentage of full time farmers is relatively lower than the national average of 63% (TNBS, 2002). This is likely due to lack of permanent cash crops around the Uluguru Mountains. As a result, farmers engage in other income earning businesses to supplement income. The main type of business carried out particularly in Morogoro Region is local making beer. Other businesses include small retail shops, selling timber, charcoal, bricks and crops.

Sixty two percent of the respondents had attained primary education (seven years); about 16% had less than standard seven education; 15% had not undertaken any formal education, and 7% had attained secondary and post secondary education. The percentage of those who had no formal education (15%) is relatively lower than the national average (33.0%). This is likely because most parts of Morogoro highlands were centres of Christian Missionaries who had put emphasis on formal education. While the majority of those who had attained standard seven and below came from Morogoro, a majority of those who attained secondary and post secondary education came from Dar es Salaam.

About 69% of the respondents belonged to the Roman Catholic (RC) faith, followed by 22% Muslims and 9% Protestants (Anglicans, Lutherans, Seventh Day Adventists (SDA), Moravians, Pentecostals, Assemblies of God, Christian Life Church, New Apostolic Church, Prophets' Church and Mennonites). Whilst 73% of the RCs came from Morogoro, 44% of the Muslims and 30% of the other Christian religions came from Dar es Salaam. The distribution of these religions reflects the historical picture: Christian missionaries concentrated on the highlands while the Arab Muslims preferred the coastal areas. About 30% of the respondents in Dar es Salaam were Protestants, compared to 8% in Morogoro.

About 58% of the respondents had received knowledge on fish farming. Of those who received fish farming knowledge 63% came from Dar es Salaam and 58% from Morogoro. Of the adopters 73% received fish farming knowledge while only 26% of the non-adopters received fish farming knowledge.

### Model specification

The dependent variables are the decision to adopt (assigned value 1) or not to adopt (assigned value 0); and the independent variables are the influencing factors (Table 2). Since the dependent variables assume only two values, 1 and 0, both probit and logit models can be used for analysis. The two models differ in terms of the distribution and the identification of the assumptions employed. There is no basis for preferring one over the other. One can make a choice based on tests and familiarity; consequently, the author chose the probit model. It is important to note that marginal effects of either model tend to be identical when values are calculated at mean.

The parameter estimates of the probit model do not offer much information apart from the sign; not much can be gleaned from these estimates. Moreover, these parameter estimates are not marginal values. Marginal values from the probit model can be obtained, given the change in the probability that the dependent va-

**Table 1.** Demographic characteristics of the sample.

Respondents characteristics		Sampled regions		Total sample n= 340 (%)
		Morogoro n= 313 (%)	Dar es Salaam n= 27 (%)	
Gender/sex	Male	75	74	75
	Female	25	26	26
Household head	Yes	78	78	78
	No	22	22	22
Marital status	Married	82	89	83
	Single	12	4	11
	Others	6	7	6
Main occupation	Full time farmer	47	22	45
	Farmer + business	51	30	50
	Farmer + employee	1	33	3
	Others	1	15	2
Education level	No formal education	15	15	15
	Less than primary education	17	4	16
	Primary education	64	37	62
	Secondary and above	4	40	7
	Others	0	4	.3
Religion	Roman Catholic (RC)	73	26	69
	Muslim	19	44	22
	Others	8	30	9
If obtained fish farming knowledge	Yes	58	63	58
	No	42	37	42
If adopters received fish farming knowledge (n=234)	Yes	71	88	73
	No	29	12	27
If non-adopters received fish farming knowledge (n=106)	Yes	27	20	26
	No	73	80	74

Source: Survey results, 2006.

**Table 2.** Definition of variables that influence adoption of fish farming technology.

Variable	Variable meaning	Type of measure	Types of responses
Adopt	If respondents adopt fish farming or not	Binary	1, if adopted; 0 otherwise
<b>Farmers' characteristics</b>			
Hhh	If respondent is household head	Binary	1, if household head, 0 otherwise
Hhf	If household head is female	Binary	1, if household head female, 0 otherwise
Sex	If respondent is male	Binary	1, if male; 0 otherwise
Age	Age of respondents	Years	Number of years in age
Age 2	Age of respondents squared	Years	Number of years squared
Edu 1	Education level of respondents	Years	Years of formal education
Rom	Religion of the respondents	Binary	1 if belonging to faith that does not impede the practice of fish farming or eat fish; 0 otherwise
<b>Household resource endowment</b>			
Know	If respondents received knowledge on fish farming	Binary	1, if received fish farming knowledge; 0 otherwise
Land	Household farm size	Acres	Number of acres

Table 2. Contd.

Hhs	Household family size	Number	Total household number
Hhlf	Household economically active members	Number	Total number of economically active household members
Move	Member of the household moves away for longer period	Number	Total number of household members moving away for long
Income	Household cash income per year	Amount	Total household cash income
<b>Technology characteristics</b>			
<b>Production part of the technology</b>			
Prof 1	Respondent ranking of activities in terms of profitability	Binary	1, if profitability of fish is ranked higher; 0 otherwise
Opc 1	Respondents ranking of activities in terms of operation cost	Binary	1, if operational cost of fish farming is ranked lower; 0 otherwise
Rew 1	Respondents ranking of activities in terms of immediacy of reward	Binary	1, if immediacy of reward of fish farming is ranked higher; 0 otherwise
Mark 1	Respondents ranking of activities in terms of marketability	Binary	1, if marketability of fish is ranked higher; 0 otherwise
Comp 1	Respondents ranking of activities in terms of complexity	Binary	1, if complexity of fish farming is ranked higher ; 0 otherwise
Status 1	Respondents ranking of activities in terms of status	Binary	1, if status of fish farming is ranked higher; 0 otherwise
Risk 1	Respondents ranking of activities in terms of risk	Binary	1, if risk of fish farming is ranked higher; 0 otherwise
<b>Consumption part of the technology</b>			
Pala 1	Respondents ranking of relishes in terms of palatability	Binary	1, if fish palatability is ranked higher; 0 otherwise
Freq 1	Respondents ranking of relishes in terms of consumption frequency	Binary	1, if fish consumption frequency is ranked higher; 0 otherwise
Easob 1	Respondents ranking of relishes in terms of easiness to obtain	Binary	1, if the easiness to obtain fish is ranked higher; 0 otherwise
Statue 1	Respondent ranking of relishes in terms of status	Binary	1, if the status of fish is ranked higher; 0 otherwise

riable is equal to one for a unit change in the explanatory variable. However, it must also be noted that the probit model is non-linear and, therefore, the marginal effects will depend on the values of the explanatory variables. As a default, most software gives marginal effects at the mean values of the explanatory variables.

The survey covered information on farmer characteristics, household resources and endowment and technology characteristics. The empirical model specified was:

$$ADOPT = \beta_0 + \beta_1 hhh + \beta_2 hhf + \beta_3 age + \beta_4 age2 + \beta_5 edu2 + \beta_6 rom + \beta_7 know + \beta_8 land + \beta_9 hhs + \beta_{10} hhlf + \beta_{11} move1 + \beta_{12} income + \beta_{13} prof1 + \beta_{14} opc1 + \beta_{15} rew1 + \beta_{16} mark1 + \beta_{17} comp1 + \beta_{18} status1 + \beta_{19} risk1 + \beta_{20} pala1 + \beta_{21} freq1 + \beta_{22} easob1 + \beta_{23} statue1 + \mathcal{E}i$$

Explanation of the above variables is in Table 2 and ( $\mathcal{E}i$ ) is the error term.

## RESULTS AND DISCUSSION

Table 3 shows that sex, age, age squared in number, education (edu 1), religious faith (rom), fish farming knowledge (know), land size (land 1), household size (hhs 1), income (income), relative profitability (prof 1) and

relative risk (risk 1) were significant in explaining the

### The influence of farmer characteristics on adoption of fish farming

Sex (sex) was negatively related to the probability to adopt fish farming. The result revealed that if the sex of the respondents is male the probability to adopt fish farming decreased. This is in agreement with results obtained by Kaliba et al. (1997) and Burton et al. (1999), which show that the probability of female farmers adopting farm technologies is higher than that of male farmers. The negative sign on the sex (sex) can be explained by the following reasons. Firstly, fish farming was mainly undertaken to produce fish for home consumption, an objective which suited females more than males. Secondly, this study has revealed that about 62% of men moved away from home for longer periods for other businesses as compared to only 27% of women. Thus, men were less likely to adopt fish farming, which requires continuous attention. Thirdly, the volume of cash

**Table 3.** Estimated marginal effects of factors influencing adoption of fish farming technology.

Variable	dy/dx*	Z**
Sex	-0.0037733	-1.77
Age	-0.0013142	-2.64
Age2	.0000144	2.6
Edu	.0010285	2.01
Rom	.008592	1.85
Know	.0382626	2.12
Land	.0006384	1.67
Hhs	.0020935	2.49
Hhlf	-.0001989	-0.21
Move	-.0004401	-0.38
Income	-1.1609	-1.79
Prof1	.3900562	2.18
opc1	-.0001807	-0.09
Rew1	.0038685	0.71
Mark1	-.0017994	-0.99
Comp1	-.0021782	-1.26
Status1	-.0000956	-0.05
Risk1	-.0224551	-1.61
Pala1	.0061988	1.2
Freqe1	.0023027	0.57
Easob1	.1544272	1.3
Statue1	.0121843	1.41

\*dy/dx is for discrete change of dummy variable from 0 to 1, \*\*Bold Z designates significant variables.

income earned from fish farming was too low (only 2.4% adoption of fish farming technology. Surprisingly all food variables were insignificant of the total earnings) to attract men. Men had more opportunities to access alternative sources of income and were less likely to adopt a low income generating activity.

Age was significant in explaining the adoption of fish farming. This result is similar to those obtained by Polson and Spencer (1991). However, while age was negatively related to the probability to adopt fish farming, the square of age (age 2) was positively related to it. This indicates that as age increased the probability to adopt fish farming decreased. This did not come as a surprise as younger farmers are more likely to try new technology and are capable of doing laborious activities like pond construction, pond repair and total harvest. Participants in PRA meetings indicated that older farmers are conservative, risk-averse and unlikely to embark on new technology.

Formal education (edu 1) was positively related to the probability to adopt fish farming technology. The sign of the variable is consistent with prior expectations. This means a farmer having higher formal education is more likely to adopt fish farming than the one with less formal education. This observation is in agreement with Kimenyé (2001), who showed that a farmer's level of for-

mal education increases the probability to adopt the improved variety. This is not surprising as fish farming knowledge was disseminated using extension pamphlets, books, newsletters and most training and seminars were accompanied by a written examination. In such a situation farmers without formal education were left out. Similarly, some aspects of fish farming such as measurement of pond size, calculation of stocking density, sex identification etc. required some formal education. In addition, farmers with higher education had greater scope of understanding and were more inquisitive and therefore more likely to try a new technology like fish farming. This is contrary to Bussolo (2007), who showed that less educated farmers were more likely to adopt coffee farming.

Religious faith was positively related to the probability to adopt fish farming. The sign of the variable was consistent with prior expectations. This study showed that, if a farmer belongs to a religious faith (Roman Catholic, Anglican, Lutheran and Moravian) which did not impede the practice of fish farming, the probability to adopt fish farming increased. This is not a surprise as some religions prohibited the practice of some activities of fish farming or eating certain fish. While Muslims and some Protestant Christians (SDA, Assemblies of God and Pentecostals) were prohibited by their faith to use local brew leftovers to feed fish, Muslims and Seventh Day Adventists (SDAs) were restricted from handling pig manure to fertilize fish ponds. In addition, SDAs were restricted from eating unscaled fish like cat-fish. If the prohibited inputs were the main source of fertilization (as was the case in some villages) and feeding, it is unlikely that fish farming would be adopted by Muslims and some Protestants. In addition, if most farmers belong to these religious groups, they may also affect adoption by discouraging fish farmers in their neighbourhood or by not eating farmed fish.

When Dar es Salaam data was dropped from the overall sample, all variables namely sex, age, age 2, education (edu 1) and religious faith which impede fish farming (rom) were significant in explaining the adoption of fish farming. The level of significance for sex, rom and edu 1 was higher. Other variables had more or less retained at the same level of significance. The signs of all variables were also the same.

### The influence of household resource endowments

Land size was positively related to the probability to adopt fish farming. The sign of the variable was consistent with prior expectations. This means farmers owning bigger farm size were more likely to adopt fish farming than those owning smaller farm sizes (Kimenyé, 2001; Bussolo et al., 2007). A possible explanation is that farmers producing on larger farm sizes had spare land for fish farming and were commercial and produced small marketable surpluses to satisfy some level of household

financial needs (Polson and Spencer, 1991) and have a high probability to take up new and/or unfamiliar activity such as fish farming. Akinola (1987) shows that because farm size was an indicator of the level of economic resources available, the probability to adopt a new technology increases as the resource base increases. Conversely, farmers producing on small farm sizes had less spare land for fish farming and produce mainly for consumption, were less flexible in accepting new ideas and tended to be risk-averse.

Household size was positively related to the probability of adoption of fish farming. The sign of the variable was consistent with prior expectations. This suggests that farmers with bigger household sizes were more likely to adopt fish farming technology. This result is similar to those of Kaliba et al. (1997), and Burton et al. (1999) which show that an additional child in a household increases the probability to adopt farm technologies. This result shows the role played by inactive members of the household (children and aged members) in the adoption of fish farming. This study found that children and aged members played an important role particularly when active members moved away from home to other businesses - a common practice in the area.

Knowledge on fish farming was positively related to the adoption of fish farming. The sign of the variable was consistent with prior expectations. This implied that respondents who had acquired knowledge on fish farming were more likely to adopt fish farming than those who did not have such knowledge. This is similar to the finding that the availability of extension services has positive influence on the probability to adopt farm technologies (Polson and Spencer, 1991; Kaliba et al., 1997; Baidu-Forson, 1999; Burton et al., 1999; Kimenyi, 2001). Often non-adopters gave the explanation that they could not adopt fish farming because pond construction was difficult and laborious. In PRA meetings conducted by this study it was found that most non-adopters likened pond construction to hole digging, not knowing that pond construction was not that difficult because a big part of soil dug from the pond was used to build the pond dike.

Surprisingly, income (income) was inversely related to the probability to adopt fish farming. This implied that as income increased, the probability to adopt fish farming decreased. This result was probably because fish farming earned comparatively less and was mainly adopted to serve nutritional purposes. PRA meetings conducted by this study indicated that some well-off farmers preferred buying farmed fish rather than having own fish ponds. This result is consistent with findings by Kaliba et al. (1997) who showed that wealthier farmers were unlikely to adopt bitter water melon.

When Dar es Salaam data was dropped from the overall probit model, all variables followed the same pattern of significance. However, the level of significance for variables like land size (land 1) and household size (hhs 1) and cash income (income) were relatively higher when Dar es Salaam was dropped. This showed the importance of

these variables in adoption of fish farming in the rural areas.

### **The influence of technology characteristics**

Relative profitability (prof 1) was positively related to the probability to adopt fish farming. The sign of the variable was consistent with prior expectations. This means fish farming is more likely to be adopted if it was more profitable than other competing activities. This is consistent with findings by Napier et al. (1991), and Baidu-Forson (1999), who indicate that farmers adopt a technology which promises greater reward than existing practices. One of the objectives of undertaking fish farming was to generate cash income. However, in achieving that objective, fish farming competes with other activities for household resources. If fish farming is to be adopted, its profitability had to be relatively higher than other competing activities. On average, the profitability of fish farming was ranked eighth in relation to other competing activities. The low profitability of fish farming relative to other activities was attributed to small pond sizes, some ponds were located too far from homesteads, poor management due to non-availability and/or high opportunity cost of inputs, stocking of poor quality fingerlings, low stocking density, unreliable market, animal predation, human theft, and pond overcrowding leading to poor growth of fish.

Relative risk (risk 1) was negatively related to the adoption of fish farming technology. The sign of the variable was consistent with prior expectations. This result suggested that the probability to adopt fish farming decreased as it became relatively more risky compared to other competing activities. This result is consistent with Batz et al. (1999) and Baidu-Forson (1999), who show that relative risk is significant in the adoption of farm technologies. This study shows that, on average, fish farming was ranked 9<sup>th</sup> in terms of risk compared to other activities. The high influence of relative risk was attributed to a risky production environment in the study area.

When Dar es Salaam data was dropped from the overall sample, both variables (prof 1 and risk 1) were significant in explaining the adoption of fish farming technology. The level of significance of both variables was a bit higher after dropping Dar es Salaam. This was likely due to the higher need for profitable activities and the higher risk of the production environment in the rural area.

### **Conclusion**

The objective of this study was to identify factors which influence the adoption of fish farming technology in selected villages in Eastern, Tanzania. The study shows that fish farming adopters were more likely to be younger, educated farmers and farmers with a religious faith which does not impede any practice of fish farming. However,

men were less likely to adopt fish farming technology. Similarly, fish farming adopters were more likely to be farmers who acquired fish farming knowledge, own bigger farm sizes and have bigger household sizes. Wealthier farmers as measured by cash income were less likely to adopt the technology. Finally the results have shown that farmers were more likely to adopt fish farming if the technology was profitable and less risky.

## RECOMMENDATIONS

The results have spurred some interesting and important recommendations. The first is that fish farming technology appears to be particularly attractive to disadvantaged groups (women and younger farmers), thus helping to address positively inequality issues. Technology developers and extension officers should incorporate a gender dimension and age to technology adoption rather than taking for granted that the technology is gender- or age-neutral as many used to think. The second is that efforts should be made to identify community belief that may conflict with a new technology before it is introduced. In some cases technology packages need to be altered in conformity with place depending on people's beliefs. For instance, composite rather than pig manure should be advised in Muslim dominated communities or tilapia rather than catfish should be introduced in SDA communities. Similarly, care should be taken not to introduce "educated man's technology to solve uneducated man's problems".

The third is that dissemination of fish farming knowledge is vital to the adoption process. Efforts should be made therefore to disseminate fish farming knowledge through various channels to potential farmers. The fourth is that efforts to promote fish farming should be directed towards farmers with resources (that is, land, labour, income, etc.) necessary to adopt the technology. Finally, technology developers should strive to improve the profitability of fish farming through investigating the possibility of reducing the risk of losing fish, shortening culture cycle to target market size fish, use of low cost inputs and/or through integrating fish farming within the existing farming system. Efforts should also be made to improve access to peri-urban or urban markets by improving roads, providing information on prices and nutrition value of fish and formation of marketing co-operatives to lower transport and transaction costs.

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