Adoption of Agroforestry Practices in Malawi: A Case Study of Gliricidia Sepium and Maize

by

P H Thangata and J R R Alavalapati

Abstract

Agroforestry as a sustainable agricultural system is being widely promoted all over the world, especially in sub-Saharan Africa. This paper investigates into the adoption of mixed inter-cropping agroforestry technology, *Gliricidia sepium* and maize, in Malawi. The differences between adopters and non-adopters of *Gliricidia sepium* in terms of their age, size of the family, extension contact, income sources and other socioeconomic variables are examined. Results from logistic analysis suggest that extension contact, size of the family, and age of the farmer are important variables in determining the adoption of agroforestry. It was observed that farmers modified technologies to suit their situation. This suggests that local participation is important in technology development.

INTRODUCTION

Agroforestry as a sustainable agricultural system is being widely promoted all over the world, especially in sub-Saharan Africa. It has the potential to improve soil fertility through the maintenance or increase of soil organic matter and biological N$_2$ fixing from nitrogen fixing tree species (Young, 1997). Therefore, for resource poor farmers who cannot afford to apply fertilizers in their farming, agroforestry practices are thought to provide best alternatives.

In Malawi, food insecurity is a major problem. It is estimated that 75% of the small farmers are deficient in maize (*Zea mays*) (Centre for Social Research, 1992). High population pressure, lower land per capita, and decline in soil fertility are important contributors to the problem. Farmers must either use chemical fertilizers or practice rotation and fallow methods to replenish soil fertility. For resource poor farmers neither is feasible. Those who cannot afford to purchase chemical fertilizers have switched to grow local maize whose yields are low. Further, fertilizer prices have risen sharply since the removal of fertilizer subsidies and most farmers have very limited access to credit (Gladwin, 1992). To qualify for credit, farmers have to grow tobacco, the only profitable cash crop. However, not many people have enough land to grow both maize for food and tobacco for cash.

This paper reports findings of a study that was conducted in Malawi in the summer of 1996. The study investigated into factors influencing the adoption of mixed inter-cropping agroforestry technology, *Gliricidia sepium* (gliricidia) and maize.

*Gliricidia* is a fast growing fodder species and a good nitrogen fixer. The International Center for Research in Agroforestry (ICRAF), after a long on-station study, instituted an on-farm evaluation of gliricidia with selected farmers in Malawi (ICRAF, 1997). The Malawi government extension agency was a key partner in this venture. A survey was conducted to explore farmers’ perceptions towards this technology and their adoption behavior. The differences between adopters and non-adopters in terms of their age, gender and other socioeconomic variables were explored.

The paper is organized as follows. In the next section, the conceptual framework used in the study is discussed. Details of survey methodology are discussed in the third section. The model specification and results are discussed, respectively, in section four and five. Finally, conclusions are provided with implications for forestry extension in Malawi.

THEORETICAL FRAMEWORK GUIDING THE STUDY

In Malawi, the adoption of agroforestry innovations has not been investigated vigorously. Some studies have been conducted to examine the adoption of agricultural technologies such as hybrid maize. It was found that the adoption of hybrid maize was declined because farmers could not afford to apply inorganic fertilizers due to cash constraints (Carr, 1997). Although agroforestry was perceived as a viable

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1. Study was conducted and first presented in partial fulfillment of MS degree, University of Edinburgh, Scotland.
2. Authors are, respectively, Graduate student and Assistant Professor, School of Forest Resources and Conservation, University of Florida, Gainesville, FL 32611.
3. In this study, we consider farmers who designed and managed technology trails on their farms. As such we consider experimenters as adopters and non-experimenters as non-adopters.
alternative to inorganic fertilizers, its adoption was also not impressive. It was thought that investigating into factors influencing the adoption of gliricidia-maize agroforestry technology would help formulate strategies to promote this technology.

Agroforestry decision making is a mental process, and is a function of needs, knowledge and perception. This process which is commonly called “innovation diffusion process” can occur different ways (Rogers, 1983; Düvel, 1994). There is no single theory of causation that can embrace all aspects of adoption and explain the traditional attitude of small farmers in developing countries (Morris and Adelman, 1988). However, the adoption behavior model (Tolman, 1961), a modification of the field theory (Lewin, 1951) is useful and more appropriate to this study. According to this model, the behavior of an individual is a function of socioeconomic and environmental factors and the objective adoption is endogenous to the sum of the interacting forces of his/her situation. As such the behavior to adopt a new technology is assumed to be intentional in this model. Following Düvel (1994), we present a graphical model of agroforestry adoption behavior in figure 1. The model explains that adoption behavior is governed by a set of intervening variables--individual needs, knowledge about the technology, and individual perceptions about methods used in meeting those needs in a specific environment. However, these intervening variables are shown to depend on a set of socioeconomic variables-- age, level of awareness, extension contact, income, and the size of the family.

In this model, it is assumed that agroforestry is ecologically feasible, economically efficient, and socially compatible in the study area. The model clearly shows the distinction between adoption and expansion of technology. Willingness to establish agroforestry technologies may largely depends on individual’s risk taking behavior. However, continuation or expansion of a technology largely depends on perceived or realized advantages of a new technology over an older technology in meeting his/her needs. In this study it is assumed that for resource poor farmers, practicing gliricidia technology is a better option over the use of chemical fertilizers. This assumption implies that farmers who adopt this technology are likely to continue or adopt in the future.

\[4\] It should be noted that household level of awareness about agroforestry practices depends on his/her contact with extension agents, neighbors, and/or mass media or participation in field days.

**Figure 1. Agroforestry (AF) adoption behavior model**

<table>
<thead>
<tr>
<th>Human (Psychological)-Environmental Factors</th>
<th>Economic-Technical Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent Variables</td>
<td>Intervening Variables</td>
</tr>
<tr>
<td>Socio-economic factors (e.g. age, awareness, household size, extension contact, income sources)</td>
<td>Needs</td>
</tr>
<tr>
<td></td>
<td>Perception</td>
</tr>
<tr>
<td></td>
<td>Knowledge</td>
</tr>
</tbody>
</table>

Modified from Düvel, 1994.

**METHODOLOGY**

**The study area**
The study was carried out in the Domasi valley farming system in Zomba rural development project (15° 22’ S, latitude and 35° 22’ E, longitude). The valley is within the Malosa Extension Planning Area (EPA). Rainfall ranges from 800 mm to 1300 mm with a good rainy season between November to April followed by scattered showers called ‘chiperoni’ rains in the cold months from May to July. The growing period is 210-270 days and soils are typically heavy textured sandy clay loam. Temperatures range from a minimum of 10-12.5°C to a maximum of 20-22.5°C. The area is densely populated with an average of 162 people/km² and reaching 500 people/km² on good arable land (ICRAF, 1996). In 1996, the EPA had a total of 17,000 farming families with land holding sizes ranging from 0.42 ha to 0.62 ha.

**Survey methodology**
Two structured questionnaires with closed and partly open-ended questions were developed to collect the required information. The questionnaires were pre-tested on two groups of farmers. The input form pre-testing exercise was used to make minor modifications in questionnaires. A total of 29 adopters and 20 non-adopters were interviewed from 27th June to 31st July 1996. In 1994, farmers from two sections, Kanache and Mbelo (Malosa EPA) had attended a field day hosted

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5 EPA is an agricultural area with the same agroecological characteristics subdivided into sections where extension agents do their work. Each section is subdivided into blocks that the extension agent visits. It is a form of modified T & V system. (See Benor et al., 1984).
by ICRAF at Makoka research station in Zomba. After a day’s visit and exposure to different soil improvement technologies, many farmers expressed willingness to try the mixed intercropping of *Gliricidia sepium* (gliricidia) with maize, a modified system of hedgerow intercropping (Maghembe et al., 1997). Later on those farmers were given gliricidia seedlings to plant in their fields. As such, these farmers were considered as adopters.

The non-participating farmers were selected from a list of 140 farmers, given by local extension agents, using a stratified random sampling technique. Thirty farmers were selected, 15 from each of the two sections, Kanache and Mbelo. Nevertheless, due to time constraints and unavailability of some farmers, only 20 were interviewed.

MODEL SPECIFICATION

A logit analysis is used to explore the relationship between adoption and socioeconomic variables of 48 farmers. The dependent variable, adoption, is dichotomized by assigning a value of one if a farmer is an adopter and zero otherwise. Because the dependent variable is dichotomous, the regression is non-linear in form and ordinary least squares will not provide useful estimators (Maddala, 1983). Instead a dichotomous logistic model technique is used to regress adoption on a set of explanatory variables.

The estimator is found by assuming a logistic distribution for error term. The probability that $Y_i=1$ is:

$$1 - F(-\beta'x_i) = 1 - (e^{-\beta'x_i} / 1 + e^{-\beta'x_i})$$

By re-arranging we get

$$e^{\beta'x_i} / 1 + e^{\beta'x_i}$$

and the probability that $Y_i=0$ is:

$$F(-\beta'x_i) = e^{-\beta'x_i} / 1 + e^{-\beta'x_i}$$

Re-arranging this we get

$$1 / (1 + e^{\beta'x_i})$$

By substituting these values into the likelihood function (Maddala, 1983), we get the following expression:

$$L = \prod_{y_i=1} [ e^{\beta'x_i} / 1 + e^{\beta'x_i} ] \% \prod_{y_i=0} [ 1 / 1 + e^{\beta'x_i} ]$$

The derivatives of the likelihood estimates of the coefficients yield the probability of being in one of the dichotomous groups, an adopter or non-adopter. This will give the measure of strength of response for the independent variables.

The equation used to estimate the parameters is:

$$Y_i = \alpha + \beta_1AGE + \beta_2NHH + \beta_3INCGENR + \beta_4EXTCT + \beta_5AFAWR$$

where $Y_i$ is the dependent variable, adoption; $\alpha$ is the constant and $\beta$s are the coefficients of each explanatory variable. Table 1 provides the details of the explanatory variables used in the above equation. The independent variables, except $AGE$ and $NHH$, are indices developed by aggregating responses to various questions. All variables are transformed into binary form. The details of cut off values used in transforming variables into binary form are given in Table 1. They are used based on the principal author’s knowledge of the study area.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
<td>Age of the household head; 1 if greater than 35 years old; 0 otherwise.</td>
</tr>
<tr>
<td>INCGNR</td>
<td>Income generating activities: 1 if the household scored more than 11 points; 0 otherwise.</td>
</tr>
<tr>
<td>NHH</td>
<td>Number of people in the household eating together.</td>
</tr>
<tr>
<td>EXTCT</td>
<td>Extension contact: 1 if household scored greater than 4; 0, otherwise.</td>
</tr>
<tr>
<td>AFAWR</td>
<td>Agroforestry awareness: 1 if household scored greater than 2; 0 otherwise.</td>
</tr>
</tbody>
</table>

Previous studies have shown that younger households are more likely to adopt (Alavalapati et al., 1995) agroforestry technologies. Therefore, we expect $AGE$ to have a negative relationship with adoption. $NHH$ is the number of people in the household. Agroforestry has been reported to be labor intensive, meaning that families with less labor can not afford to take up the technology. As such we believe that $NHH$ variable will have a positive impact on adoption.

$INCGENR$ measures farmer’s sources of income to meet basic necessities. The sources included are selling own farm produce and small scale trading activities (owning a grocery, buying and selling farm produce). It is hypothesized that farmers

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6 The average life expectancy for men and women in Malawi is about 43 years (World Bank, 1999).
with more sources of income are less likely to adopt agroforestry. Farmers with more sources of income are likely to purchase chemical fertilizers. Therefore, we expect a negative relationship between INCGENR and adoption.

EXTCT represents the extent of farmer’s contact with extension agents. It comprises information such as farmer’s visits to the extension worker for advice or visits by the extension worker to provide advice, attendance to extension meetings, and attendance to a course in the extension planning area. Extension contact is a key variable in developing a favorable attitude among farmers towards the technology. Therefore, it is hypothesized that extension contact will have a positive impact on agroforestry adoption.

AFAWR is made up of information such as whether the farmer has seen or heard of agroforestry, participated in on farm trials before, and attended a field day before. We expect that AFAWR will have a positive relationship with adoption. This means that farmers with higher levels of awareness are more likely to adopt agroforestry.

RESULTS AND DISCUSSION

The summary of the descriptive statistics reported in Table 2 shows that adopters were younger than non-adopters. The adopters had more extension contact and had more people in their households than non-participating farmers. One interesting result is that non-adopters’ awareness is higher than that of adopters. This may be because agroforestry is not a new technology in this area and the question asked to elicit awareness was not specific to the mixed intercropping of Gliricidia and maize. The results also show that there is no much difference between the two groups in their sources of income.

Table 2. Summary statistics of the model variables used in estimating agroforestry adoption

<table>
<thead>
<tr>
<th>Var. Name</th>
<th>Sample (n=48)</th>
<th>Adopters (n=28)</th>
<th>Non-adopters (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Std. Dev.</td>
<td>Mean Std. Dev.</td>
<td>Mean Std. Dev.</td>
</tr>
<tr>
<td>AGE</td>
<td>51.13 14.44</td>
<td>49.68 14.78</td>
<td>53.15 14.1</td>
</tr>
<tr>
<td>INCGENR</td>
<td>12.06 3.72</td>
<td>12.04 3.37</td>
<td>12.10 4.25</td>
</tr>
<tr>
<td>NHH</td>
<td>5.29 2.64</td>
<td>5.82 2.87</td>
<td>4.55 2.14</td>
</tr>
<tr>
<td>EXTCT</td>
<td>3.71 2.62</td>
<td>5.29 2.19</td>
<td>1.50 1.15</td>
</tr>
<tr>
<td>AFAWR</td>
<td>2.29 1.38</td>
<td>2.07 1.46</td>
<td>2.60 1.23</td>
</tr>
</tbody>
</table>

Table 3 reports the results of a logistic regression analysis.

Table 3. Summary of Logistic regression model for the probability for adopting agroforestry

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Estimate Coefficient</th>
<th>Std. Error</th>
<th>T-Ratio</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
<td>-2.161</td>
<td>1.156</td>
<td>-1.869*</td>
<td>-0.663</td>
</tr>
<tr>
<td>INCGENR</td>
<td>-0.200</td>
<td>0.730</td>
<td>-0.273</td>
<td>-0.040</td>
</tr>
<tr>
<td>NHH</td>
<td>0.319</td>
<td>0.166</td>
<td>1.925*</td>
<td>0.060</td>
</tr>
<tr>
<td>EXTCT</td>
<td>3.145</td>
<td>1.249</td>
<td>2.518**</td>
<td>0.306</td>
</tr>
<tr>
<td>AFAWR</td>
<td>-0.055</td>
<td>0.825</td>
<td>-0.066</td>
<td>-0.008</td>
</tr>
<tr>
<td>Constant</td>
<td>0.019</td>
<td>1.046</td>
<td>0.018</td>
<td>0.007</td>
</tr>
</tbody>
</table>

**Significant at 5%  * Significant at 10%

Maddala R² 0.304 LR test 17.42
McFadden R² 0.267 Correct predictions 73%

All the variables except AFAWR have expected signs. AGE is shown to have negative effect on adoption and it is significant at 10% level. The elasticity value on this coefficient explains that holding other explanatory variables constant, young farmers are 66% more likely to adopt this technology than old farmers. This may be because younger people have longer planning horizons and may be more willing to take risks than older people. Both EXTCT and NHH variables are positive and significant, respectively, at 5% and 10%. This indicates that extension contact and household size are important factors in influencing the adoption of this technology.

With illiteracy rate of above 60%, for farmers in Malawi, extension contact may be an effective way to develop a favorable attitude towards agroforestry. This suggests that government should focus on strengthening its extension arm. Carter (1995) and Maghembe (1996, pers. Comm.), noted that practicing agroforestry technologies require more labor and households with more people have an advantage over households with fewer people. However, Adesina (1999) cautions that large families can have a negative effect on the adoption as they often have lower land per capita. The other reason for this positive relationship may be due to social obligation. In extended families, households with a responsibility of providing a livelihood for all members of the family tend to adopt this technology more.

Farmers in the study are mostly resource poor with little variation in their sources of income. Furthermore, the objective of adopting the technology under investigation is to get around the problem of limited access to expensive fertilizers. The negative sign on INCGENR supports that farmers with more sources of income are less likely to adopt this technology.
Surprisingly, *AFAWR* did not turn out to be a significant variable and has an unexpected sign. However, a closer examination of the study area and nature of technology provide insights for this result. Agroforestry technologies are not new to this area and many non-adopters of mixed inter-cropping of gliricidia and maize might have adopted other agroforestry technologies. As such adopters of the technology under investigation may have lower awareness of agroforestry technologies than that of non-adopters. Also, many non-participating farmers may be aware of this technology and waiting to see how this technology will perform in fellow farmers’ fields.

**CONCLUSIONS**

This paper examined the factors that influence the adoption of mixed inter-cropping of gliricidia and maize in Malawi. Diffusion of innovation theory was used as framework to develop an empirical model. The results suggest that younger farmers are more likely to adopt agroforestry. This result supports the findings of Alavalapati et al. (1995) and Boahene et al. (1999). It was found that farmers with larger families are more likely to adopt this technology when compared to farmers with smaller families. However, results from this study do not confirm other studies that farmers who adopt agroforestry technologies are wealthier than non-adopters. It may make sense because the objective behind the promotion of this technology is to alleviate the problems associated with the use of high cost fertilizers. Better off households can afford to use high cost fertilizers. As such there is less necessity for them to adopt this technology. The results support the findings of Omorogbe (1998) that farmers with higher extension contact are more likely to adopt the technology.

In Malawi, farmers’ major source of information about agroforestry technologies is the government extension system. With an illiteracy rate of over 60%, for farmers in Malawi, contact with extension agents may be a better way to get information about agroforestry technologies. This implies that improving the quality of extension system is of paramount importance in Malawi. In providing effective services, extension agents are expected to conduct frequent meetings with farmers within their jurisdiction. However, limited means of transportation preclude them to conduct frequent meetings with farmers. Also, with a large jurisdiction, the farmer extension agent ratio is very high in Malawi (Sigman, 1995). Allocation of more funds to extension agencies, splitting the area into more manageable sections, and/or introduction of para-extensionists may improve the quality of extension services in Malawi.

There is ample evidence of the need to involve local farmers in setting farming research agendas (Merrill-Sands and Collion, 1993) and in developing new technologies (Rogers, 1990). This was evident when adopters in this study modified the technology introduced by the ICRAF. For example, adopters shifted the ridges so that gliricidia and maize were on the same ridge in one season and on separate ridges in the other season as opposed to the ICRAF’s suggestion of maintaining the same ridges. This observation supports the argument that an innovation changes as it diffuses (See Eveland, 1977 and Rogers, 1983). This re-invention provides a good feedback to research and development practitioners (Hildebrand, 1988). Involvement of farmers at the technology development stage will reduce the time lag between discovery and its subsequent adoption by farmers (Welch, 1971).

Finally, we would like to point out some of the limitations and future research directions. The sample on which the analysis was conducted is small. We think that the results portray a realistic picture of the Malawian farming system. We have considered only gliricidia and it may be worthwhile to examine other tree species under different management practices of maize. Besides the set of variables used in the analysis, many other public policies may have influence on the adoption of agroforestry technologies. For example, subsidies on export agricultural commodities will discourage farmers to grow subsistence crops like maize. As such the adoption of mixed inter-cropping of gliricidia and maize may be low. Incorporating the effect of those variables is beyond the scope of this paper.

**Acknowledgements**

Thanks are due to the SADC-ICRAF project in Zomba, Malawi and the farmers of Kanache and Mbelo sections.

**REFERENCES:**


7 These are local farmers who can read and write or unemployed secondary school graduates.


