PRODUCTIVE LAND USE SYSTEMS
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INITIAL FINANCIAL EVALUATION OF HEDGEROWS

by

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EXECUTIVE SUMMARY: INITIAL FINANCIAL EVALUATION OF HEDGEROWS

This analysis, based on available information and assumptions, indicates that Leucaena hedgerows utilized either as forage or for soil amendment should be a very attractive investment for many Haitian farmers. The analysis considers the difference in outlays and incomes between the existing use of the land (farmed without hedgerows) and the expected use of the land (farmed with hedgerows used either as forage or as soil amendment).

The calculated internal rates of return (IRR) for an investment in hedgerows-utilized-as-forage is over 80 percent for the base-case scenario. The factor causing this very attractive rate is the high relative profitability associated with the forage produced on the hedgerows. Marketing the forage through an animal produces 40 percent more revenue and less labor expense than the crops (corn and beans) given up when the hedgerow is installed.

The calculated IRR for an investment in hedgerows-utilized-as-soil-amendment is over 75 percent for the base-case scenario. The factor causing this very attractive rate is the significant increase and stability in crop yields assumed to result from the use of hedgerow clippings used as soil amendment.

Sensitivity tests of the values used in the analysis of the hedgerow-utilized-as-forage indicate that the very favorable conclusion given above is quite robust to changes in assumption values. The deepest drop in the calculated IRR (to 22 percent) was obtained by reducing the rate of hedgerow installation from 5 meters per hour to 1 meter per hour. Lowering the assumed hedgerow forage yield to one-fourth of its expected value reduced the IRR to about 29 percent. A similar reduction occurred when the number of animals produced per dry matter ton of forage was reduced by 50 percent. In all other tests, the IRR remained above 30 percent with most results lying above 50 percent.

CONCLUSION AND RECOMMENDATIONS

We would expect farmers to be avid adopters of the hedgerow whether they used its annual production of biomass for fodder or for soil amendment. If the farmers are not adopting the practice as we expect, then, the Project and the farmers must not share the same understanding of the hedgerow. To address this situation, we must first be certain that our understanding of the productivity of the hedgerow is correct. This implies a research effort to verify our productivity assumptions. The sensitivity analysis results imply that technical data collection efforts relating to understanding hedgerows-utilized-as-forage should be focused on animal production per dry matter ton of forage, hedgerow yield, and hedgerow installation time. Fully understanding the hedgerow-used-as-soil-amendment requires verification of the critical assumption, used in the analysis, on the difference in yields between hedgerow-

protected plots and traditionally farmed plots.

Next we must understand the farmers' point of view. Clearly, in the interest of efficiency and in the context of a client-oriented mode of implementation, the Project's response to lower-than-anticipated adoption rates should be based on the farmers' view of the problems. This implies a socio-economic research effort.

THE NEXT STEP

This analysis rests on pieces of information and assumptions. Thus, each datum and assumption must be understood and critiqued by the reader before the analysis can be fully useful. Thus, readers with technical backgrounds and better knowledge of the farming systems than this economist are encouraged to examine closely the entire analytical process and the assumptions and value ranges used to identify possible errors or data limitations that should be addressed in the next iteration of this analysis.

I have set-up the analytical model in a fashion that facilitates sensitivity testing. So, I invite readers to suggest for testing specific assumption sets, perhaps, with regionally specific values.

ACKNOWLEDGEMENTS

I would like to thank those team members who have reviewed an earlier draft of this paper, namely, Frank Brockman, Dennis Shannon, Greg Brady, and Abdul Wahab. Their comments were given in the spirit of the general call for critique announced above and caused a substantial re-evaluation of the IRR. I would also like to thank others who have contributed information, namely, Mike Bannister and Dean Treadwell.

REZIME

PREMYE EVALWASYON FINANSYE RANP VIVAN

Analiz sa-a, ki baze sou enfòmasyon disponib ak sou kèk sipozisyon, montre ranp vivan lesena itilize kòm manje bèt ou byen pou angrese tè kapab trè enteresan pou anpil agrikiltè ayisyen. Analiz la konsidere diferans lajan ki envesti ak lajan ki rapòte lè yo konpare fason yo itilize tè-a kounye-a (san ranp vivan) ak lòt fason yo ta ka itilize tè-a (ak ranp vivan ki sèvi kòm manje bèt ou byen pou angrese tè-a pou bay plis randman).

Lè yo kalkile benefis ranp vivan itilize kòm manje bèt bay, sa yo rele nan ekonomi to randman entèn (an franse "taux de rendement interne"; an angle "Internal Rates of Return: IRR"), li plis pase 80%. Sa ki esplike benefis sa-a se manje bèt ranp vivan-an bay. Lè ranp vivan finn enstale sou tè-a, bèt ki manje fouray ki soti nan ranp vivan sa yo rapòte 40 pousan plis kòb e aktivite sa-a mande mwens travay pase lè agrikiltè-a plante kilti tankou mayi ak pwa.

To randman entèn jaden ranp vivan itilize pou angrese tè plis pase 75%. Rezon ki esplike benefis sa-a, se rekòt yo ki vin ogmante e ki vin pi regilye akòz fèy ranp vivan yo ki angrese tè-a.

Nan analiz sa-a gen yon seri tès yo fè pou wè si done yo byen chita. Tès yo montre chif yo jwenn pou ranp vivan itilize kòm manje bèt ase solid. Yo jwenn to randman entèn ki pi ba yo (jiska 22%) lè yo diminye vitès pou enstale ranp vivan yo de 5 mèt a 1 mèt nan inè de tan. Lè yo desann randman fouray ranp vivan-an a yon ka (1/4) de sa li ta sipoze bay, to randman entèn nan diminye a 29%. Li desann tou lè yo redwi a mwatye kantite bèt ki pwodwi pou chak tòn fouray ranp vivan-an bay. Nan tout lòt tès yo, to randman entèn nan rete pi wo pase 30% - majorite chif yo pi wo pase 50%.

KONKLIZYON AK REKOMANDASYON

Dapre rezilta sa yo, nou ta atann agrikiltè yo ta trè enterese adopte ranp vivan pou sèvi ak biomas yo (fèy ak branch ranp vivan yo) ou byen kòm manje bèt ou byen pou angrese tè pou bay pi bon rekòt. Si sa pa ta fèt sa vle di agrikiltè yo ak pwojè-a pa konprann teknik ranp vivan-an menm jan. Nan ka sa-a, nou ta dwe mande tèt nou si fason nou konprann randman (pwodiktivite) ranp vivan-an kòrèk. Sa sipoze yon efò pou chèche verifye sipozisyon ki pèmèt nou fè analiz la. Rezilta analiz pou kontwole si done yo solid ta dwe baze sou rasanble done teknik sou itilizasyon ranp vivan kòm manje bèt. Sa vle di chèche konnen sitou sa bèt la pwodwi pou chak tòn manje sèk ki soti nan ranp vivan-an, kantite fèy ak branch ranp vivan-an ka bay, ak tan pou enstale ranp yo. Pou byen konprann itilizasyon ranp vivan pou angrese tè-a, li mande pou verifye sipozisyon ki fèt nan analiz la pou tabli diferans randman jaden ki gen ranp vivan ak jaden ki pa genyen ranp vivan.

Answit, nou dwe konprann jan agrikiltè-a wè kesyon-an. Pou pwojè-a kapab efikas e kòm apwòch li baze sou sa kliyan-an vle, yo ta dwe konsidere sa agrikiltè-a panse. Si to adopsyon yo pi ba pase sa yo atann, repons pwojè-a ta dwe baze sou fason agrikiltè-a wè pwoblèm yo. Sa ta mande yon rechèch sosyo-ekonomik.

PWOCHEN ETAP

Analiz sa-a chita sou kèk enfòmasyon ak kèk sipozisyon. Kidonk, moun k-ap li papye sa-a dwe byen konprann, dwe kritike chak done ak sipozisyon ki fèt nan analiz sa-a anvan yo sèvi ak rezilta yo. Teknisyen ak moun ki konnen sistèm peyizan-an plis pase ekonomis ki fè travay sa-a, ta dwe ekzamine analiz la an detay, tout sipozisyon ki fèt yo, tout tès ki pèmèt identifye erè posib ak limitasyon done yo. Sa ta ka itil pou pote koreksyon nan fason analiz yo fèt.

Mwen fè modèl analiz sa-a yon fason pou fasilite tès pou kontwole sansiblite done yo. Ositou, mwen envite moun k-ap li papye sa-a pwopoze kèk seri sipozisyon espesial, petèt ki gen enpòtans rejional, pou teste yo.

REMESIMAN

Mwen ta renmen remèsye moun nan ekip pwojè-a ki te bay kèk lide sou premye bwouyon papye sa-a, mwen vle pale de Frank Brockman, Dennis Shannon, Greg Brady ak Abdul Wahab. Lide yo bay te rantre nan mòd kritik nou sot pale yo e yo te pèmèt nou pote chanjman nan evalwasyon to randman entèn yo. Mwen ta renmen remèsye tou moun ki ba nou kèk enfòmasyon pou fè analiz la, mwen vle pale de Mike Bannister ak Dean Treadwell.

INTRODUCTION

The goal of this analysis is to provide information useful to decision-makers in deciding "what to do" about hedgerow interventions promoted by PLUS. It is hoped that this information will assist project decision makers to decide what (if any) modifications need to be made in the techniques used to promote hedgerows or in the hedgerow technological package itself. Decision makers should also find the analysis useful in deciding what (if any) additional information needs to be developed.

The objectives of this initial analysis of hedgerows promoted by PLUS are:

1. to determine what information could be developed relating to the financial performance of hedgerows using existing information, and
2. to demonstrate the state of existing information relative to a more precise financial analysis.

In the following material, I will describe the analytical procedure, highlight the assumptions used, discuss the sensitivity analyses and related findings and draw conclusions from the analysis. I illustrate the sensitivity test results with graphs. The results are also provided in tabular form. Appendix A illustrates the spreadsheet model used in the analysis.

METHODOLOGY

I determined the internal rate of return (IRR) of the stream of changed investment input and output for an investment in a Leucaena hedgerow over a ten-year period. The analysis is done via spreadsheet, set-up in a fashion that allows sensitivity testing of the impact on the IRR of changes in basic assumptions used. This also will allow us to test specific sets of assumptions suggested by interested readers.

First, I developed a base-case scenario in which I assumed what I considered to be reasonable and conservative values for the critical variables in the analysis. Then, in a sensitivity testing phase, I selected individual variables, changed their values and recalculated the IRR. These changed values and associated IRRs are displayed in the graphs. While testing one variable, I held the values of all other variables at their base-case levels. Note that this method does not provide information on the synergistic effect of changing more than one variable simultaneously. Sensitivity testing was restricted to the scenario involving hedgerows-used-as-forage.

ASSUMPTIONS

Here I discuss the major assumptions used in the analysis. I would appreciate your critique of these assumptions and suggestions where

I might obtain additional relevant data.

1. The hedgerow is placed in a hillside plot used for two annual crops of maize-bean association.

2. The amount of land under production can not be expanded to provide room for the hedgerow. In other words, the hedgerow reduces the amount of land available to produce the primary crops. Note that, if the amount of land could be costlessly expanded, there would be no reduction in the associated crops and the installation of the hedgerow would be relatively inexpensive. This would enhance the value of the hedgerow investment. In a land-constrained situation, such as found in most parts of Haiti, I believe the assumption that the amount of land a farmer works cannot be easily expanded is the most appropriate assumption. This implies that the value of the crops replaced by the hedgerows is an important cost of hedgerow installation.

3. The stream of input and output values for the internal rate of return analysis is the difference in investment and product value between a traditionally farmed plot and the same plot farmed with the addition of hedgerows. So, I am considering only those elements of the farmer's operation that will change with the installation of hedgerows on 5-meter spacings.

4. Product Value. As a measure of product value, I have used sales revenue minus the labor costs of producing, harvesting, and making the product ready for market. I assumed a one hectare production area and reduced the amount of revenue and expense associated with the traditional crops to accommodate the appropriate reduction in these values when the hedgerows are in place. Specifically, I used data presented by Taylor, p. 36, for an (one hectare) associated crop of maize and beans as follows.

Number of person days labor for operations on both crops:

soil preparation	33 days
planting	10 days
weeding	9
Total	51 days

Number of person days for operations exclusive to maize:

harvesting	8.33 days per ton
post harvest processing	11.00 days per ton
Total	19.33 days per ton

Number of person days for operation exclusive to beans:

harvesting	75 days per ton
post-harvest processing	11 days per ton
Total	86 days per ton

So, I calculated expenses as: ((51 days)*(2 seasons)*(# ha.)+(19.33 days)*(tons maize harvested)+(86 days)*(tons beans harvested))*(value of labor per day).

5. Harvest time for forage (or biomass) is a critical value because it represents the major expense associated with forage (or biomass) production and, thus, has a major impact on the profitability of the new practice relative to the traditional practice. Harvest time for forage is also a major uncertainty. I have found two conflicting figures: one calculated from Taylor, the other from Fleming and Karch. I have used figures relating to rice monoculture, given by Taylor, p. 59, to estimate that one crop from a hectare of forage can be harvested in 42 days or that 3 crops can be harvested in 126 days. Fleming and Karch, p. 26, use 3 labor-days as estimate of time required to harvest three crops of forage from 100 square meters. This implies 300 labor-days per hectare or almost twice as much as calculated from Taylor.

   In the base-case analysis, I have used 50 labor-days per harvest and have assumed that there will be three harvests per year (3*50=150days). Following Fleming and Karch, I assume that the total dry matter harvested in one year will be 20 tons. I use this tonnage to calculate that each ton of dry matter forage will require 7.5 to 15 labor-days (150/20=7.5 to 300/20=15) to harvest.

6. Rate of decline of crop yields in fields not protected by hedgerows is assumed to be:

after 1 year	18%
after 2 years	21%
after 3 years	27%
after subsequent years	27%.

   These assumptions have been provided by Brockman, personal communication, who referred to Shannon; Nye and Greenland; and GRET-FAMV in making this suggestion.

7. Rate of change of crop yields behind hedgerows is assumed to be:

	Forage Hedgerow	Soil Amendment Hedgerow
year 1	-20%	-30%
year 2	-10%	+27%
year 3	0%	+21%
year 4	-18%	+18%
year 5	-21%	0%
year 6	-27%	0%
subsequent years	-27%	0%.

   These assumptions have been provided by Brockman, personal

communication, who referred to Kang, et al.; Nye and Greenland; and GRET-FAMV in making this suggestion. These figures reflect the assumptions relating to the impact the hedgerow biomass will have on crop yields. In the case of the forage hedgerow, the biomass production is harvested for animal fodder; thus, there is very little contribution to soil fertility from the hedgerow. In contrast, when the biomass is used as a soil amendment, there are substantial increases in crop yields in years 2, 3, and 4 with yields stabilizing thereafter.

8. Value of maize is assumed to be H$0.40 per kilo(Haitian dollars). Value of beans is assumed to be H$0.60 per kilo.

9. Maize-bean association yield per hectare is 500 kg maize and 200 kg beans in a single cropping season.

10. Number of maize and bean crops per year is 2.

11. Hedgerow area per hectare when hedgerows are installed on 5 meter intervals is 0.2 hectares. Source is Treadwell and Cunard, Working Document No. 14, p. 2.

12. Yield and value of traditional fodder. Yield per hectare is assumed to be equal to the yield of dried grain. Source: calculated from Aldrich et al., p. 14. The value of this stover is assumed to be 10% of the value of Leucaena fodder.

13. Value of forage grown on the hedgerow is expressed as the market value of goats it can produce. The per ton dry matter basis value of Leucaena fodder is expressed through the off-take (number of young goats sold per female) times the sales price. It is assumed that each ton (dry matter basis) of forage will support one small ruminant unit, a female and her two yearly offspring for one year. Source is Treadwell and Cunard, Working Document No. 17, p. 10.

14. Price of year-old goats weighing 10-15 kg is H$30.00 - H$35.00. Source is Treadwell, personal communication.

15. Yield of Leucaena fodder per hectare is as follows. The source of these figures is Brockman, citing work by Shannon, and Kang, et al. Brockman's comments relating to these and other data are provided in Appendix B.

Year 1:	5.1 tons/hectare from solid stand
Year 2:	11.8 tons/hectare from solid stand
Year 3:	19.0 tons/hectare from solid stand
Year 4:	25.5 tons/hectare from solid stand
Subsequent years:	same as year 4.

To obtain the quantity produced on the hedgerows in the base-

case scenario, one would multiply these figures by 0.2 since the hedgerow area amounts to 0.2 hectares.

16. The cost of installing hedgerows is calculated by multiplying the number of meters per person-hour (5 meters/hour) reported by PADF in Fleming and Karch, p. 7 by the number of meters per hectare by an assumed labor cost of H$2.00 per person-day. Additional information provided by M. Bannister suggests that the installation rate could be less than one-half the 5 meters per hour rate.

SENSITIVITY ANALYSIS

I have selected the following basic assumptions for testing the sensitivity of the results relating to the forage hedgerow to changes in these assumptions. In making the analyses, I changed the assumed value of the variable being tested over a range of values considered to be reasonable or potentially realizable and recalculated the IRR. The values of all other variables were held constant at their base-case values. Note that this method does not provide information on the synergistic effect of changing more than one variable simultaneously. The significance of changes in these assumptions can be seen in the graphs associated with each sensitivity test. The values are also presented in Table 1.

1. The number of meters of hedgerow installed per hour. This number multiplied by the assumed cost of labor represents a major portion of the hedgerow investment cost. Available estimates range from about 2.5 to 5 meters per hour. Sensitivity tests show a doubling of the associated IRRs over this range of installation time estimates. What appears to be a very attractive investment under the base-case scenario (which assumes 5 meters per hour) could actually be an investment with one-half the productive capacity. Thus, more precise information is needed on this variable before the attractiveness of the hedgerow can be fully appreciated. The graph associated with this test is shown in Figure 1.

2. Yield of fodder. The higher the yield of fodder per area of hedgerow, the more attractive the hedgerow investment. To test this assumption, I varied the assumed fodder yield from 5 to 30 tons per hectare (on a solid stand basis) and found the related IRRs varied from less than 30 percent to more than 70 percent. The graph associated with this test is shown in Figure 2.

3. Numbers Produced and Value of goat. The value of a given yield of fodder is directly related to the price and number of animals produced from the fodder. I used a goat because I had information on goats and felt goats would be more likely be able to use the type of fodder produced than would other animals. Ruminants are the only animals reported to be

capable of utilizing Leucaena as 100 percent of their diet without harmful effects (Office of International Affairs, pp. 41-52). Also, there appears to be an opportunity for increasing the quality of goat produced and thereby receiving a substantially higher market price for the animal (Treadwell, personal communication). In actual practice, an animal other than a goat may be more appropriate for specific farming systems. However, this may require the addition to the farming system of additional sources of food for the animals, perhaps, by substituting other plants for some of the Leucaena.

Under the base-case assumptions, the more valuable the goat and/or the more goats produced per ton of forage, the more attractive is the hedgerow investment. The graphs associated with these tests are shown in Figure 3 and Figure 4.

4. Time required to harvest the fodder. During that portion of the cropping year in which a crop is behind the hedgerow, manual harvesting of the fodder is required to prevent damage to the crop by the animals. The more time required the less attractive is the hedgerow investment because the higher harvest expense lowers the resulting net return to management. In the graph associated with this test, Figure 5, this relationship is seen as a downward sloping line.

5. Value of crop (maize-bean association) behind hedgerow. Hedgerows placed on 5 meter-intervals as normally prescribed by extension agents occupy 20 percent of the cropping area. The value of the crops previously occupying the space used by the hedgerow is a cost of the hedgerow investment. The less valuable the crops, the more attractive is the hedgerow investment because the striking, positive difference in profitability between the hedgerow fodder and the traditional crops becomes more pronounced.

In the sensitivity analysis I varied both maize yield and bean yield independently. Here again, one would expect synergistic effects. The associated graphs are shown in Figures 6 and 7. These two line graphs slope downward to the right reflecting the fact that the more valuable are the crops given up to install the hedgerow the less attractive the hedgerow investment becomes.

FIGURE 1.

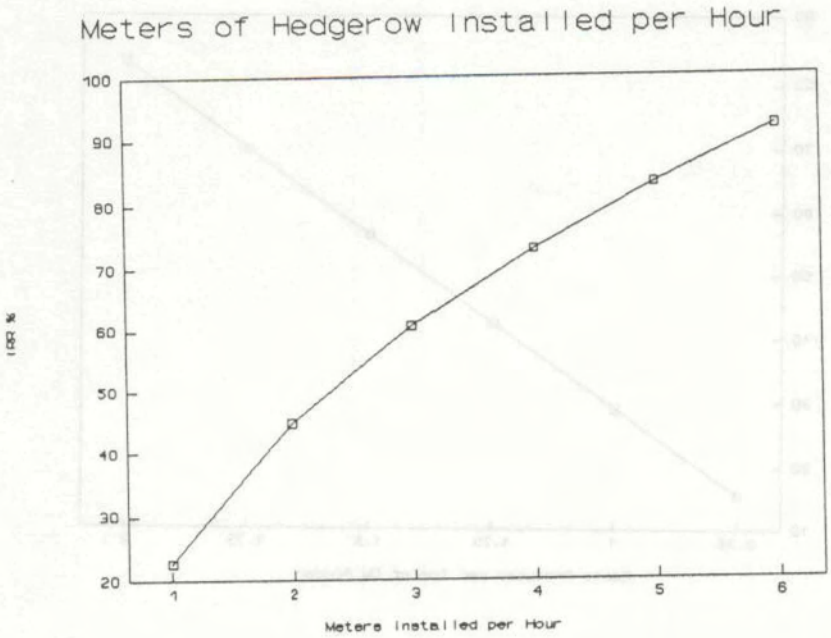

FIGURE 2.

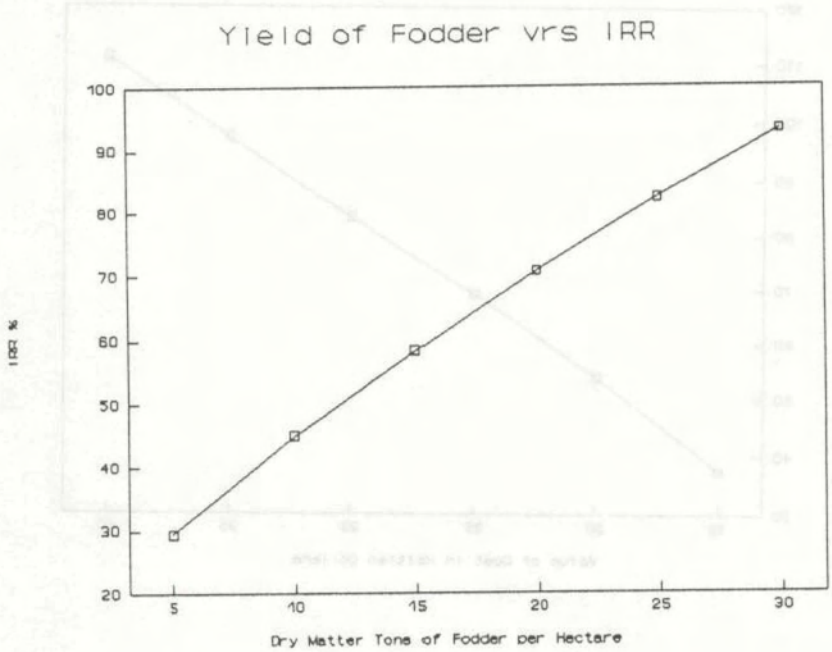

FIGURE 3.

Animals Produced per Ton Fodder vrs IRR

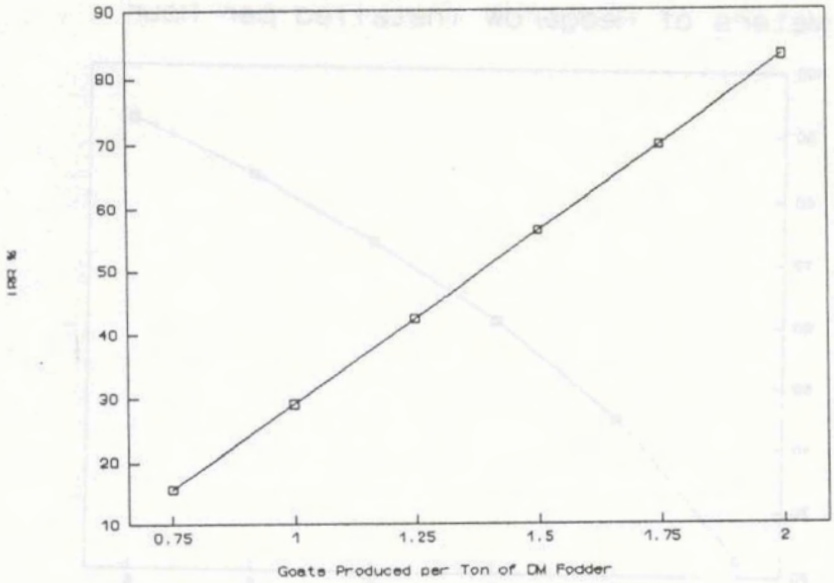

FIGURE 4.

Value of Goat Vrs. IRR

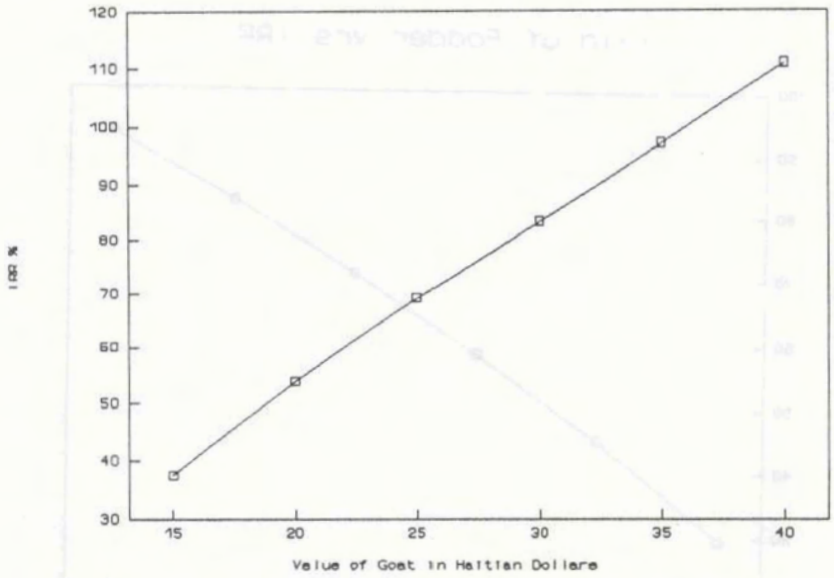

FIGURE 5.

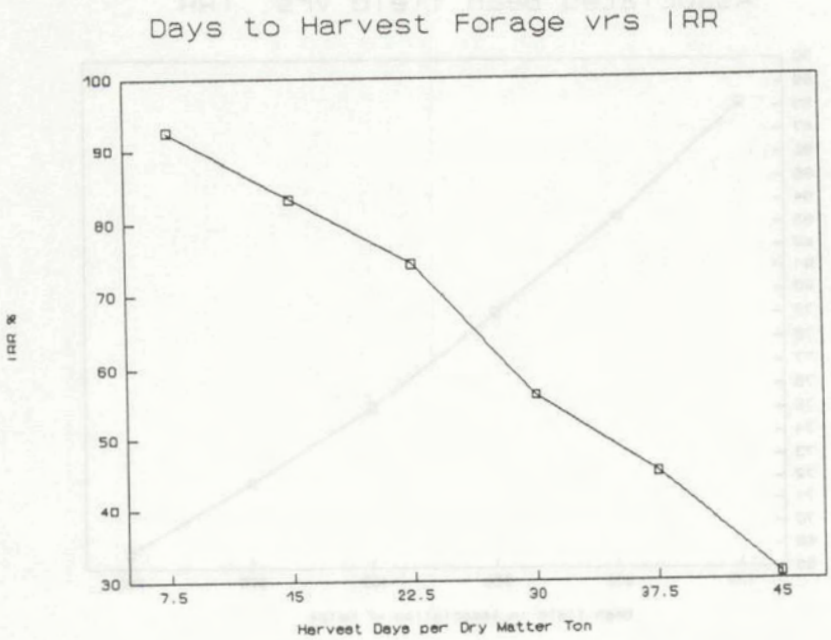

FIGURE 6

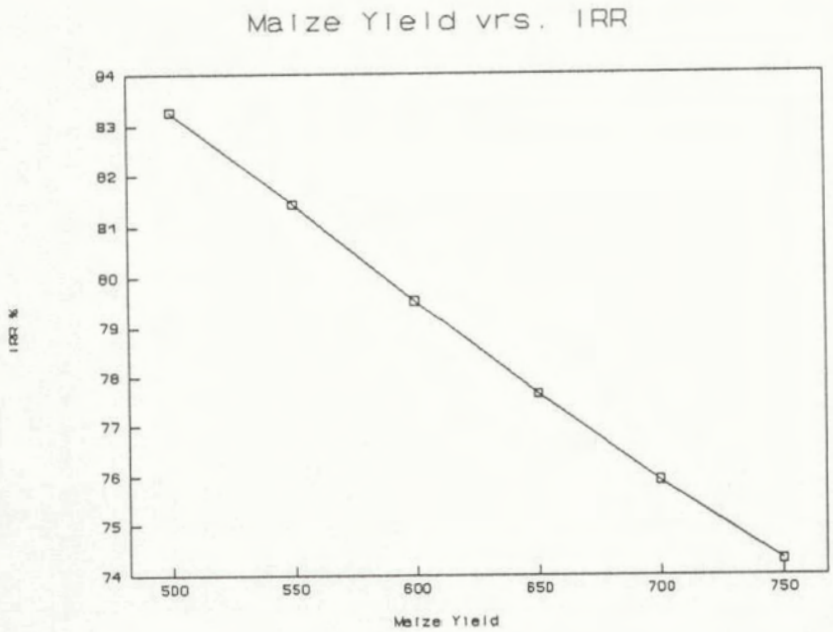

FIGURE 7.

Associated Bean Yield vrs. IRR

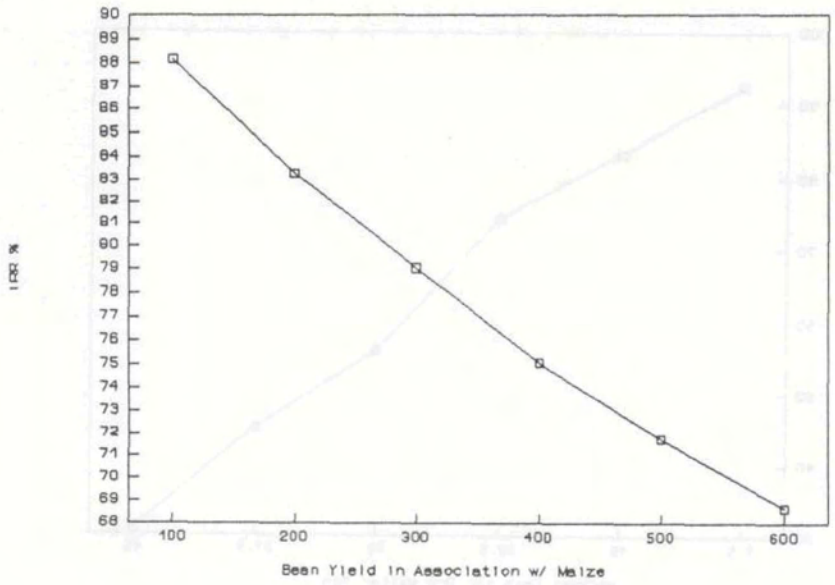

TABLE 1

SENSITIVITY ANALYSIS RESULTS

Value of a Goat $	IRR	Number of Goats Produced per Ton Fodder $	IRR	Time to Harvest Fodder Days	IRR
15	37.47%	1	29.1%	7.5	92.5%
20	53.94%	1.25	42.3%	15	83.3%
25	69.12%	1.5	56.3%	22.5	74.2%
30	83.26%	1.75	69.8%	30	56.2%
35	97.02%	2	83.3%	37.5	45.1%
40	110.73%	2.25	97.1%	45	30.9%

Maize Yield per hectare Kg	IRR	Bean Yield per hectare Kg	IRR	Hedgerow Fodder Yield per hectare DM Tons	IRR
500	83.3%	100	88.2%	5	29.4%
550	81.4%	200	83.3%	10	45.0%
600	79.5%	300	79.0%	15	58.4%
650	77.6%	400	75.1%	20	70.7%
700	75.9%	500	71.8%	25	82.1%
750	74.3%	600	68.7%	30	93.2%

Labor Cost Per Day $H	IRR	Value of Traditional Fodder $H	IRR	Meters of Hedgerow Installed Per Hour M	IRR
$1.00	107.1%	$2.00	83.9%	1	22.5%
$1.20	102.2%	$4.00	83.6%	2	44.8%
$1.50	95.1%	$6.00	83.3%	3	60.7%
$1.80	88.2%	$8.00	82.9%	4	73.1%
$2.00	83.3%	$10.00	82.6%	5	83.3%
$2.20	78.2%	$12.00	82.3%	6	91.9%

Explanations of the relationships seen between variables here are given in the text under the heading: Sensitivity Analysis.

CONCLUSIONS

Considered as an investment, Leucaena hedgerows, used either as forage or as soil amendment should be very attractive for Haitian hillside farmers for whom the assumptions of the analysis hold.

Analytical Results Relating to Forage Hedgerows

The calculated internal rate of return (IRR) for the investment in a forage hedgerow is over 80 percent for the base-case scenario. The factor causing this very attractive rate is the very high relative profitability associated with the forage produced on the hedgerows. Marketing the forage through an animal produces 40 percent more revenue and less labor expense than the crops (corn and beans) given up when the hedgerow is installed.

Sensitivity tests of the values used in the analysis indicate that this very favorable conclusion is quite robust to changes in the underlying assumption values. The deepest drop in the calculated IRR (to 22 percent) was obtained by reducing the rate of hedgerow installation from 5 meters per hour to 1 meter per hour. Lowering the assumed hedgerow forage yield to one-fourth of its expected value reduced the IRR to about 29 percent. A similar reduction occurred when the number of animals produced per dry matter ton of forage was reduced by 50 percent. In all other tests, the IRR remained above 30 percent with most results lying above 50 percent. These results imply that project data collection efforts relating to understanding hedgerow adoption rates could be focused on these three, relatively-simple-to-obtain variables, animal production per dry matter ton of forage, hedgerow yield, and installation time.

Recommendations Relating to Forage Hedgerows

The high profitability of animal production relative to crop production (corn and beans) provides an incentive through which the project could address its dual objectives of increased farmer income and soil conservation. Thus, working through animals may be an effective method of promoting soil conservation. One concludes that decision makers interested in promoting the use of hedgerows on small-scale Haitian farms should consider promoting the hedgerows as fodder production units. This implies that project decision makers should consider modifications in technical recommendations to maximize the value of the forage and parallel modifications in extensions messages to assist producers interested in forage production.

Helping farmers produce more forage is only one step. Providing farmers with training or technical inputs that improve the productive performance of animals utilizing the forage should also enhance the attractiveness of cultivating forage and indirectly the attractiveness of forage hedgerows. Helping them market the forage, either through their own animals or alternative marketing

arrangements, may also be essential in gaining widespread adoption. Efforts to improve marketing channels may become more important as the increased animal production causes reduced farm-level prices.

Analytical Results Relating to Soil Amendment Hedgerows

The calculated internal rate of return (IRR) for the hedgerow-used-for-soil-amendment is over 75 percent for the base-case scenario. The factor causing this very attractive rate is the significant increase and then stabilization in crop yields assumed to result from the use of hedgerow clippings as soil amendment.

Crop yields associated with the soil-amendment hedgerows are assumed to increase significantly during the second, third, and fourth years and then remain constant. This is in dramatic contrast to the yields on the unprotected, traditional plot where crop yields are assumed to drop 18 percent after the first cropping year, 21 percent after the second year, and at a continuous rate of 27 percent per year thereafte. Thus, the difference in net income between the soil-amendment hedgerow plot and the unprotected, traditional plot provides an impressively large return to the investment in hedgerows.

Recommendations Relating to Soil-Amendment Hedgerows

The project needs to develop tangible evidence of the expected benefits of soil-amendment hedgerows. This is the purpose of long-term experiments being conducted by SECID researchers. It is also the objective of current monitoring and evaluation activities being carried out by the PLUS project.

Since the benefits of soil-amendment hedgerows accrue over time, an appropriate extension program may also require continuous effort over time. Simply establishing demonstration plots requires three to four years. Project extension methodologies and the expectations relating to Project outputs should be modified accordingly.

Implications for Project-Sponsored Research

In light of these very favorable rates of return and mounting evidence that Project PLUS farmer-clients in some areas are not avidly installing and managing hedgerows, one concludes that something is wrong with either the hedgerow technology itself or the extension system delivering it to farmers. To address this problem, the Project should first be confident in its estimates of the productivity of the hedgerows under various climatic conditions. This should be the focus of Project-sponsored technical research.

Secondly, the Project should understand and document, for research and extension use, farmers opinions of the hedgerow and the constraints they face in adopting and managing the hedgerow either for

forage or soil-amendment objectives. Opinions can include misinformation or the lack of information that should be addressed through extension efforts. Opinions can also reveal short-comings of the technology as a component of the farmers' existing management system. These short-coming should then be addressed through extension education efforts or through changes in the hedgerow technology.

Constraints can include technical problems such as the inability of components of the technological package to perform as expected in certain environments. Constraints can include the lack of financial, institutional or managerial resources. As with all investments, the attractiveness of the hedgerow for a given farmer depends on the rates of return on alterative investments and opportunity costs of resources under the farmer's control. The hedgerow may be an attractive but unaccessible investment for many farmers because they do not have the necessary investment capital or available labor time.

Constraints can be managerial or institutional. For example, farmers may not have an appropriate animal or institution (market for fodder or cooperative animal production venture) for valorizing the fodder. They may not be managing the hedgerow in a way that provides even the lowest level of yield assumed here.

Clearly, the Project's response to lower-than-anticipated adoption rates should be based on the farmers' view of the problems. This type of social research, which is similar to the product-level marketing research done by private-sector businesses, should be the focus of Project-sponsored social research.

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APPENDIX A. BASE CASE SPREADSHEET MODEL

Initial Evaluation of Hedgerows
Traditional crop: Maize/Beans Association
Values expressed in Haitian Dollars

Value of maize:	$0.40
Value of beans	$0.60
Size of field: ha	1
Yr. yield/hectare: Leucaena DM ton	25.5
Yield per hectare: maize	500
Yield per hectare: beans	200
Crops/year	2
Yield per year: maize	1000
Yield per year: beans	400
Hedgerow area (% of field area):	0.2
Meters of hedgerow installed per hour	5
Labor cost per day in Haitian dollars	$2.0
Harvest labor-days per dm ton fodder	7.5
Fodder production:	
Maize fodder equal to grain yield	
Leucaena yield in tons/ha	25.5
Value of one year-old animal	$30
Number of animals per year	2
Value of Leucaena/DM ton:	$60
Value of Trad. fodder/DM ton	$6

IRR: 83.26%

Traditional Practice					Hedgerow-Protected Plot					Difference
crop yield		change in yield	fodder DW tons	Prod. Value	change in yield	crop yield		Leucaena fodder DW tons	Prod. Value	In Product Value
maize	beans		a.	b.		maize	beans			
1000.0	400.0	0	1.00	334.5	-0.2	800	320.0	1.02	312.57	-22.0
820.0	328.0	-0.18	0.82	237.6	-0.1	720.0	288.0	2.36	329.88	92.3
647.8	259.1	-0.21	0.65	144.9	0	720.0	288.0	3.80	394.68	249.8
472.9	189.2	-0.27	0.47	50.7	-0.18	590.4	236.2	5.10	383.55	332.9
345.2	138.1	-0.27	0.35	0.0	-0.21	466.4	186.6	5.10	316.92	316.9
252.0	100.8	-0.27	0.25	0.0	-0.27	340.5	136.2	5.10	249.26	249.3
184.0	73.6	-0.27	0.18	0.0	-0.27	248.6	99.4	5.10	199.86	199.9
134.3	53.7	-0.27	0.13	0.0	-0.27	181.4	72.6	5.10	163.80	163.8
98.0	39.2	-0.27	0.10	0.0	-0.27	132.5	53.0	5.10	137.47	137.5
71.6	28.6	-0.27	0.07	0.0	-0.27	96.7	38.7	5.10	118.26	118.3

a. DW tons tradition fodder equals (crops/year)*(crop yield)/1000 kg
b. Prod. Value (revenue minus labor expense) includes value of fodder and grain (expenses: (51 cultivation days/crop)*(# ha)*(# crops/yr)*(labor value) plus harvest & post harvest labor: (19.33)*(maize harvest tons)*(labor value) plus (86 days)*(bean harvest tons)*(labor value).

Financial analysis of decision to put in hedgerows:
What is internal rate of return of the difference in revenue between the two alternatives?
Assumption: Value of labor to install hedgerow on hectare is
(2000 m/ha)/(5 m/hr*6 hr/day)*(2 $H/pday)=$H $133
Investment in goats is 1 goat per dm ton forage
Goat has 4 year productive life, residual value of .75 of purchase price.

Difference in Product Value	Goat Investmt c.	Net Investmt d.	Net Benefit	Investmt Period	Present Value of Investmt	Present Value of Benefit	IRR Rate 83.26%	Discount factors	
-21.97	30.6	185.90	0.00	0.00	185.90	0.00		1	-185.901
92.28	40.2	40.20	92.28	1.00	21.94	50.35		0.545660	52.082
249.82	43.2	43.20	249.82	2.00	12.86	74.38		0.297745	206.6185
332.87	39	39.00	332.87	3.00	6.34	54.08		0.162467	293.8732
316.92	7.65	7.65	316.92	4.00	0.68	28.10		0.088652	309.2739
249.26	10.05	10.05	249.26	5.00	0.49	12.06		0.048373	239.2055
199.86	10.8	10.80	199.86	6.00	0.29	5.28		0.026395	189.0575
163.80	9.75	9.75	163.80	7.00	0.14	2.36		0.014403	154.0469
137.47	7.65	7.65	137.47	8.00	0.06	1.08		0.007859	129.8227
118.26	-114.75	0.00	233.01	9.00	0.00	1.00		0.004288	233.0061
			Total Present Value		228.686	228.686			

c. Difference in Product Value = product value from hedgerow-protected plot minus product value produced on a traditional plot.
d. Net Investment equals (cost of installation) + (loss of income) + (goat investment)

APPENDIX B

BROCKMAN'S COMMENTS ON AN EARLIER DRAFT OF THIS REPORT

HAITI PRODUCTIVE LAND USE SYSTEMS PROJECT

SECID/Auburn University

To : Zach Lea Date: 25 May 93

From : Frank Brockman Copy to:

Subject: Financial Evaluation of Hedgerows

Your "Initial Financial Evaluation of Hedgerows" is very interesting and should stimulate much useful discussion. I would like to start the ball rolling by referring to some of Dennis Shannon's work (SECID/Auburn Agroforestry Report No. 30). This work was carried out in Zaire but it gives us some additional figures that, in a first approximation, we can play with. (It should be noted that this work on alley cropping was carried out on a level site where erosion was not an important factor.)

The results of this research provide information related to at least two of the assumptions made in the financial evaluation:

(a) Rate in decline in crop yields in fields without hedgerows. In the financial evaluation, it is assumed to be 2% per year for ten years in the base-case analysis and in the sensitivity analysis the range of values used is 1-6%. However, in the research referred to, the decline in maize yields was estimated to be 18%, 21 %, and 27% in the first, second and third years, resp. This is in line with observations on traditional cropping systems in humid forest and savanna zones in many regions (including Haiti) in which land was cropped for only 2-4 years and then laid fallow for long periods of time [GRET-FAMV, 1990 (p. 329); Nye and Greenland, 1965 (p.127)]. As mentioned the rates of decline cited above were determined in a situation where erosion was not a factor. If it were a factor, the rate of decline would be expected to be even greater.

(b) Fodder Yield. In the financial analysis, it is assumed to be 2 tons/ha on a dry weight basis <u>from hedgerows</u> (10 tons/ha from a solid stand) in the base-case analysis. The derivation of this value (from Treadwell and Cunard, 1992) is, I believe, questionable and it appears to be low by a factor of more than 2X. For one thing, it is based on an extrapolation of biomass determination made in the second cutting at 11 months after planting. Shannon's work shows biomass production (from hedgerows 4 m apart) to be very low in the first few seasons but to increase to 6.0 to 6.3 tons/ ha (assuming 30% dry matter content and 80% biomass useable as forage) after 2 1/2 years. At five meter spacing of hedgerows, as in the model, yields could be expected to be 80% of these, i.e. 4.8-5.2 tons/ha (or 24-26 tons/ha from a solid stand).

Another assumption that I would question is that with hedgerows which are managed for forage production there will be an increase in crop yields over time. It is true that runoff should be reduced and

infiltration rates increased. However, if hedgerow prunings are not applied to the soil, there will be a decrease in soil fertility (see Kang, et. al.). I would expect that in the long run the decline in soil fertility would have a greater influence on crop yields than the improved soil moisture status.

I believe it would be of interest to run the analysis using the following values for the base-case:

Rate of decline of yields in fields without hedgerows:
After 1 year 18%
After 2 years 21%
After 3 years 27%
After each subsequent year, assume 27%

Fodder yield:
Year 1: 1.02 tons/ha (5.1 tons/ha from solid stand)
Year 2: 2.36 tons/ha (11.8 tons/ha from solid stand)
Year 3: 3.80 tons/ha (19.0 tons/ha from solid stand)
Year 4: 5.10 tons/ha (25.5 tons/ha from solid stand)
Subsequent years: same as year 4

Rate of increase/decline of yields in fields with hedgerows. (This is wild speculation based on assumptions that: (1) in first year yields would be reduced in proportion to land area lost to hedgerows, (2) that yield loss would be reduced progressively in next few years as effect of hedgerows on improving soil moisture status is observed and (3) that eventually the decline in soil fertility will result in a progressive decline in yields):

Year 1: -20%
Year 2: -10%
Year 3: 0%
Year 4: -18%
Year 5: -21%
Year 6: -27%
Subsequent years: -27%

If the lines of reasoning used in making these assumptions have validity, after a certain period of cropping, land between hedgerows would have to be allowed to return to fallow or planted to a soil improving crop (e.g. herbaceous legume).

I will attempt to follow this with some figures to be used in an analysis for the case where the hedgerows are managed for soil fertility improvement rather than for forage production.

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To: Zach Lea
From: Frank Brockman
Date: 5 Aug 93
Subject: Financial Evaluation of Hedgerows

I've been threatening to give you some numbers to be used in an analysis for the case where hedgerows are managed for soil fertility. Here's a set, again from Shannon's work in Zaire:

Rate of decline of yields in fields w/o hedgerow (as before):
After 1 year : -18%
After 2 years: -21%
After 3 years: -27%
After each subsequent year: assume -27%

Rate of increase/decline in fields with hedgerows:
Year 1: -30%
Year 2: +27%
Year 3: +21%
Year 4: +18%
Subsequent years: assume 0%

If this looks interesting, I'll spell out the assumptions.