Agrosearch
Vol. 2, Nos. 1& 2, 1996. pp 67 - 79

SELECTING AN OPTIMAL FARM ENTERPRISE COMBINATION IN TRADITIONAL AGROFORESTRY SYSTEMS USING PORTFOLIO MODEL ANALYSIS.

OLUWEMIMO OLUWASOLA
Department of Agricultural Economics and Farm Management
University of Ilorin
Ilorin, Nigeria.

ABSTRACT

The portfolio model revealed that agroforestry farmers allocated more land to agricultural crops relative to forest crops in the ratio 80.7 to 19.3. The expected return was N1,316.63 for forest crops and N2,305.54 for agricultural crops per hectare. Various levels of agricultural and forest crop combinations to reduce risk to enterprise were made. Less risk-aversed farmers will plant more of forest crops on their agroforestry farms. The tolerable minimum risk system is an agroforestry system in which 80% of the land is allocated to forest crops and 20% is used for agricultural crops. A major constrain to higher earnings from traditional agroforestry farms is that resources are not fully tapped as tree crops are largely incidental to major agricultural crops.

Key words: *Traditional Agroforestry, Optimal Farm Enterprises combination portfolio model analysis.*

INTRODUCTION

Recent developments in the field of agricultural resource utilization have shown that there is excessive pressure on resources of land,soil,water and forest. In developing nations including Nigeria, this has resulted from a combination of factors including increases in human population; inability to improve on traditional farming practices of shifting cultivation; the continued use of crude energy sapping implements of hoes, cutlasses and fire; unbriddled mechanization; increasing urbanization and a stagnating economy that has forced over 80% of the citizenry to depend on these natural resources for sustenance. The implication of this has been in the unsustainable exploitation of agricultural resources leading to massive environmental and resource degradation.

In response to the dwindling productivity of land and resource degradation, research institutions like the International Council for Research in Agroforestry (IITA) have recommended and promoted agrofrestry farming practices to replace the traditional methods of shifting cultivation.

According to King (1979) "agroforestry is a sustainable land management system which increases the overall yield of the land, combines production of agricultural crops (including tree crops) and forest plants and/or animals simultaneosly or sequentially on the same unit of land, and applies management techniques that are compatible with the cultural practices of the local population". Agroforestry practices vary between cultures. They include the Nigerian compound farms of the Igbos (Okigbo and Greenland, 1976); the Kandy gardens of Sri Lanka (McConnel and Dharmapala, 1978); the Indonesian homesteads (Harwood and Price, 1976) as well as others involving perennial culture. Each of these systems is based on an upper storey of trees and palms that may produce timber,fruits, nuts, fuelwood and shade; a middle storey of cocoa, coffee, fruits and spice bushes; and a ground storey of bananas, maize, beans and root crops (Watson 1983). Alley cropping and alley farming were recently introduce by ICRAFF and IITA, 1977; Kang *et al* 1980).

A number of research work have lent strong support to the advantages of agroforestry farming methods. Young (1979) pointed out that they can check erosion as well as be used in land reclamation. Akobundu (1980) and Yemoah *et al* (1986) reported that agroforestry is effective in weed control. A number of research work have shown that weed control constitute over 40% of farmers operational cost (Akobundu 1980; Oluwasola 1993). Sumberg *et al* (1987) established that agroforestry systems replenish soil fertility and thus make it more profitable than traditional fallow systems.

In spite of the advantages of agroforestry farms, farmers have not responded positively to all efforts to sell the system. Rather, farmers have continued to practice shifting cultivation using traditional implements with their attendant effects on natural resources.

The reasons for not adopting the ICRAF/IITA agroforestry system are not far fetched;

(i) the supply of fuelwood which is one of the attractions of alley farming in East Africa is not in short supply in the humid and forest areas of Nigeria. In addition, there are other more efficient and relatively cheaper and cleaner alternative sources of energy.

(ii) there is the possibility for the cultivation of economic trees like cocoa, coffee, citrus, kolanut and mango which make the cultivation of leguminous trees unattractive.

(iii) rigid cultural practices which introduces an element of risk in the adoption of an unknown or untested farming practices to peasants, and

(iv) the failure to incorporate farmers preferences in the development of the system.

In South Western Nigeria is the traditionally cultivated cocoa farms. Alvim and Nair (1986) pointed out that traditional cultivation of cocoa farms present an agroforestry system. It is shade tolerant and is grown in association with other species either in selectively cleared forest or more commonly with food crops that provide early shade until the shade trees planted along with cocoa take over as the upper storey. Peasant farmers are at home with this and thus, encouraging the farmers to combine it with food crops is a sure way of checking the current wave of deforestation, land and soil degradation. However, the risk involved in terms of variability in income and, the profitability of such an enterprise must be carefully analysed to ensure that they are capable of attracting small scale farmers.

This paper is thus aimed at

1. evaluating the economic performance of agroforestry farms;

2. showing how to reduce risk in the variation of expected income from traditional agroforestry farms using the portfolio model;

3 suggesting the optimum number and level of optimum choice/combination of enterprise.

METHODOLOGY

This study was conducted in Ondo State of Nigeria between 1991 and 1992. The state has a total land area of 20,595 km^2 out of which 3,298.2 km^2 or 16.9% is put under settlement development, tourism and agriculture. In addition there are fallow lands swamps and water bodies of rivers and lakes. The population of the state increased from 2.7 million in 1963 to 3.9 million by 1991 (C.B.N. 1994). This thus increases the population density from 131 persons per km^2 to 189 persons per km^2. The area is intensely cultivated for both food and tree crops. A major problem arising from this is soil erosion. Millions of Naira have been expended to combat erosion in various parts of the state, all of which points to need for agroforestry development to check resource degradation.

Data were obtained from ninety farmers from three local government areas viz Ekiti West, Ekiti South West and Irepodun/Ifelodun using structured questionnaire. The data were analysed using the portfolio model analysis. The model is specified as

$$ENPV = W_iNPV_i + (1-W_i)\ NPV_j \quad \text{..........} \quad (1)$$

where

ENPV is expected net present value.
NPV is net present value.
W_i is fraction of land planted to crop i.
i is agricultural crops.
j is forest plants.

Portfolio theory is used by decision makers to select among alternative possibilities with outcomes expressed by probability distribution so as to maximize expected utility in an uncertain environment (Dillion 1971; Arrow 1974). The net present values in equation n(2) are future estimates of revenues and cost which are subject to risk and can be expressed as standard deviation (or variation) from the expected estimates. Thus the risk of the agroforestry system as proposed by Blandon (1985) can be specified as

$$\sigma_s = \left(w_i\sigma_i^2 + \sum_i^m \neq \sum_j^m w_iw_j\,\sigma_{ij}\right)^{\frac{1}{2}}$$

where

σ_s is the risk represented by standard deviation.

σ_i^2 is variance of the expected net income of agricultural crops.

σ_{ij} is covariance of the net income of the agricultural and forest crops

w_j fraction of land planted to crop j
w_i, i, and j are as defined above.

There were two main constraints to an exhaustive development of the portfolio model as is possible in financial economics. First there was the difficulty of obtaining accurate information on the proportion of land used for each of the several products on the agroforestry farms as they were intimately mixed. Secondly, the farmers had a combination of crops which varied from one farmer to the other. The forest crops include kolanuts, walnut, citrus, oil palm, forest trees and wildlife. Agricultural crops were cocoa, plantain and yams. Farmers chose some of these two groups and combined them variously on the agroforestry farm.

To facilitate an easy and meaningful analysis, the farm products were grouped into two: forest crops and agricultural crops.

The hectarage of land allocated to the two groups as well as the revenue yielded were then estimated.

RESULTS AND DISCUSSION

The result from the analysis showed that the age of farmers averaged 56.5 years (Table 1). This has implications for risk bearing and productivity as both tend to diminish with age. Seventy three or 81% of the sampled farmers will at any given time prefer to cultivate agroforestry farms that has cocoa as the main crop. These factors are important in trying to recommend any agroforestry system in the study area.

On the average, 80.7% of the cultivated farmlands which averaged 3.5 hectares per farmer were allocated to agricultural crops, notably cocoa and plaintain; while the rest 19.3% went to forest crops. This pattern of land allocation is quite understandable if it is appreciated that the purpose of incorporating the forest crops into the cocoa farm did not arise principally from economic or subsistence reasons. Rather, they were meant to provide shade for the agricultural crops (particularly cocoa) against excessive sunlight, to protect them against rain and wind storms and, to serve as boundary plants.

Net earnings per hectare was #1,316.63 with a standard deviation of ~431.68 for forest crops and #2,305.54 with a standard deviation of #937.58 for agricultural creps. The risk-income variability is thus 40.7% for agricultural crops. Comparatively, the forest products have a lower risk income ratio of 32.8%.

The results of the portfolio model analysis are summarised in Table 2 to show income and risk levels for various levels of enterprise combination of forest and agricultural crops in an agroforestry system. From the table, there are several decision rules that can be followed taking cognizance of the return and risk values as well as the level of risk-aversion of the decision maker.

Where the decision rule for example is a straight choice between agricultural and forest crops, the farmer who is less risk aversed may choose the alternative with the highest pay off and thus specialize in planting only agricultural crops. This yields a net income of #2,305.54 per hectare. However, this amount provides the highest risk per Naira value which is given by the covariance of 0.41. A more conservative farmer who is highly aversed to risk may choose the alternative that offers the least amount of risk per Naira. Thus, forest crops with an expected income of #1,316.68 and coefficient of variation of 0.33 will be planted over the entire farmland.

The calculated coefficient of correlation between the forest and agricultural crops was 0.3275. This provides a statistical measure of the degree of independence between the earnings from forest and agricultural crops. The low correlation coefficient value indicates that there is a weak correlation between the agricultural and forest crops and suggest that diversification between the two groups would be a useful risk reducing strategy.

Several decision rules can be used to choose between different levels of crop combination(s) in the diversification process.

When the coefficient of variation is used as the basis of decision making, complete specialization in either forest or agricultural crops does not provide the 'best' decision strategy as they have high risk per Naira value of earnings, being 0.41 for agricultural crops and 0.33 for forest crops. Of all the combination levels II to X in Table 2, the 'efficient' choice of forest and agricultural crop combination is allocating 80% of the land to forest crops and 20% to agricultural crops as this yielded the lowest coefficient of variation of 0.29.

Another decision rule is selecting the alternative with the highest lower bound. This rule is useful in a situation where the farmer feels that a net return below a certain level will be insufficient to meet personal and family financial obligations. A handy statistical measure of the lower bound is two standard deviations below the mean in which case planting 60% of the land with forest crops and 40% with agricultural crops is "best" as it yielded the highest lower bound pay-off value of #670.35. Thus the diversification alternative for traditional agroforestry caused a decrease in expected earnings which confirms Budowski's (1982) fear that agroforestry is likely to show a slower return when compared with annual crops. However, it brought about a reduction in the risk associated with the variability of income.

The decision strategies open to the farmer are illustrated in Figure 1 showing the expected incomes and the standard deviations of the crop combination levels; and Figure 2 showing the expected incomes and risks in terms of the coefficient of variation. On these are shown the maximum efficiency possibility set (curve Q) and the risk-return indifference curves of two decision makers. The decision maker whose risk-return utility function is represented by I_1 I_2 (i.e highly aversed to risk) would choose to specialize or forest crops if the choice was limited to one of forest and agricultural crop and will thus stay on risk-return utility curve I_1. When given the option of diversification between the two, he moves up curve Q to indifference curve I_2 which becomes the highest possible indifference curve as it is tangential to the curve Q. Similarly, the decision maker who is less risk aversed with I'_1, I'_2 indifference curves will move from I'_1 (producing only aggicultural crops) to I'_2.

The results presented show that the criteria of expected returns, coefficient of variation and the maximum lower bound rule lead to different levels of forest and agricultural crop combinations being chosen. The important point is that combinations of both crops will always dominate complete specialization in one or the other as long as the returns from the two are less than perfectly correlated. The actual decision rule for a potential investor will depend on the risk aversion level of the decision maker.

Figures 3 and 4 show the application of risk return analysis to all combination of assets as with an agricultural enterprise in which a limited resource(s) like cropland has alternative uses. The shaded area represents the opportunity set and it contains all possible combinations of the risky farm asset. The efficient set consists of asset portfolios that are dominant relative to the others resulting from the fact that for any given level of expected income, their risk is lowest; or , for any given level of risk their expected incomes are highest. The efficient set will consist of combinations of risky assets because of the reduction in risk due to diversification among individual assets whose returns are not highly correlated.

The optimal portfolio of the risky asset is at point K which is the point of tangency between the efficient set and the highest attainable risk-return indifference curve I_2. Any combination level on I_1 is inefficient while that on I_3 is unattainable. The efficiency set curve in Figures 3 and 4 indicate that any addition of forest crop from point I to IX which is a progressive substitution of forest crop for agricultural crops is efficient. Beyond that level, the curve bends back indicating increased risk for a decreasing income and thus any combination within that area is clearly inefficient.

Point IX is important as it represents the tolerable minimum risk system i.e. the minimum risk presented at which diversification is just efficient and for which income is not lower than risk at that level of crop combination. In the study area therefore, the minimum risk system is one in which 80% of the land is allocated to forest crops while the rest 20% is used for agricultural crops.

RECOMMENDATION AND CONCLUSION

As shown in the presentation of results, forest crops combined with cocoa could be a useful risk reducing management strategy especially as income from cocoa are controlled by exogeneous market forces. Field investigations showed that a lot of potential economic opportunities were not tapped which reduced net earnings. It is therefore suggested that:

1. Since crops like pine-apple (Ananas comosa) and walnut can do well in traditional agroforestry, farmers should see them beyond merely providing refreshments in-between meals. They should be exploited and/or commercialised. This they can do by increasing their production especially as their cultivation does not necessarily reduce the number of cocoa trees cultivable in the farm.

2. Where the nature of the soil makes it impossible to adopt coca dominated agroforestry but permits arable farming, arable crops should be combined with leguminous trees to ensure soil fertility replenishment. The use of multipurpose trees will encourage farmers to develop such agroforestry systems. Trees like the locust bean (*Parkia clappertoniana*); shea butter (*Butyrospermum parkii*) and kola nut when combined with food crops will increase farm income. In addition some tree species could be medicinal while leguminous trees and litter fall will enrich soil fertility.

3. The study showed that various crops are found in the traditional agroforestry farms. Going by the size of peasant farms, with the exception of one or two crops, others may not occur in sufficient quality for commercial exploitation. It is therefore recommended that the number of crops in an agroforestry farm unit be limited to a manageable commercial quantity. For example, from these groups A to D;
   A = tree plants and walnut
   B = Cocoa
   C = Kolanut/Oil palm/Citrus/Mango
   D = Plantain/Pine apple/Yam/Cocoyam

a farmer may choose to combine crops in A+B+one of C+one of D instead of having all the crops in a single farm.

In conclusion, it is hoped that greater resources will be channelled into the practice of traditional agroforestry systems that are in conformity with the cultural practices of the local farmer. Theresource endowment in the study area does not favour the development of any other type of agroforestry. It is doubtful if farmers will bc willing to plant lcguminous trccs with food crops in preference to cocoa, kolanut and oil palm trees. The advantage of fuelwood derivable from leguminous trees/food crop agroforestry is not likely to be attractive in a forest environment where fuelwood is not in short supply and in a country with cheaper energy-fuel alternatives.

Thcrcforc, it is morc worthwhilc to understand the traditional agroforestry systcms and find ways of improving thcm with respect to the number and variety of foodcrops that can be added into such systems.

REFERENCES

Akobundu, I.O. (1980). "Live Mulch: A new approach to weed control and crop production in thc tropics" British Crop Protection conf. Weeb. pp.377-380.

Alvim, R. and P.K.R. Nair (1986). Combination of Cocoa with other Plantation crops: An Agroforestry System in South East Bahia, Brazil. *Agroforestry Systems* 4(1): 3-15.

Arrow, K.J. (1974). Essays in the Theory of Risk Bearing. Amsterdam. North Holland Publishing Co.

Blandon, P. (1985). Agroforestry and Portfolio Theory. *Agroforestry Systems* 3:239-249.

Budowski, G. (1982). Applicability of Agroforestry Systems in Agroforestry in the Humid tropics by L.H. Macdonald (Ed), Ibadan, Nigeria, United Nationd University.

Central Bank of nigeria (1994). Statistical Bullettin. 5(2): 130.

Dillon, J.L. (1971). An Expository Revie v of Bernocillian Decision Theory in Agriculture. Is Utility futility? *Review of Marketing and Agric. Econs.* 39:3-80.

Harwood, R.R. and E.C. Price (1976) Multiple cropping in Tropical Asia. *Multiple Cropping* ASA Special Publication No. 27 Madison; American Society of Agronomy. pp11-40.

International Institute of Tropical Agriculture (1978). Annual Report for 1977.

Kang, B.T., Wilson C.F. and I. Sipkcns (1980) Alley Cropping in southern Nigeria. *Plant and Soil* 63: 163-179.

King, K.F.S. (1979). Agroforestry (a New System of Land Management): Agrforestry Proc. 50th. Tropische Landbouwdag (Symposium on Tropical Agriculture) Bullettin 303 Dept. of Agric Research Koninklijk Instituut voor de Tropen, Amsterdam.

McConnell B.J. and K.A.E. Dharmapala (1978) The Forest Garden Farm of Kandy. A paper based on Farm Management Rcport No. 7 Economic Structurc of Kandyan Forest- Garden Farms. F.A.O. Agricultural Diversification Project, Peradeniya, Sri Lanka.

Okigbo, B.N. and D.J. Greenland (1976) Intercropping Systems in Tropical Africa. *Multiple Cropping* A.S.A. Special publication No.27; Madison. American Society of Agronomy. pp 63-101.

Ondo State of Nigeria:(1977) *Annual Report on the Forestry Adminstration of Undo State* M.A.N.R., Akure, pp2 3.

Oluwasola, O. (1993) Probability of Agroforestry Farm in Ondo Statem Unpublished Ph.D Thesis, Department of Agric. Economics, Obafemi Awolowo University, Ile-Ife, Nigeria.

Sumberg, J.,McIntire,J.,Okali,C and A. Atta-Krah (1978) Economic Analysis of Alley Farming with Small Ruminants. ILCA Bulletin 28th Sept. pp 2 6.

Watson, G.A (1983) Development of Mixed

Tree and Food Crop systems in the Humid Tropics:A Response to Population Pressure and Deforestation. *ExperimentalAgriculture* 19(4):311-332.

Yemoah C.F., Agoola A.A. and K. Mulongoy (1986) Decomposition, Nitrogen Release and Weed Control by Prunnings of Sellected Alley Cropping Shrubs. *Agroforestry Systems* 4:239-246.

Young A. (1979) Ten Hypotheses for Soil-Agroforestry Research. Agrofestry Today ICRAF Bulletin. Nairobi. Kenya. March pp. 13-16.

Table 1: Age Distribution of Respondents.

Age of Respondents (Years)	Ekiti-West	Ekiti SouthWest	Irepodun/ Ifelodun	Total	percentage
31-40	2	1	-	3	3.3
41-50	11	9	10	30	33.3
51-60	10	12	10	32	35.6
61 70	7	6	8	21	23.3
71-80	-	2	2	4	4.4
No. of Respondents	30	30	30	90	100.0
Mean age of Respondents	55.0	56.8	57.7	56.5	

Source: Fielkd Survey 1991/1992

Table 2: Expected Returns, standard Deviations: Coefficients of variation and lower Bounds for selected Combinations of Forest and Agricultural products in Traditional Agroforestry

Combination Levels	Proportion of Cropland		Expected Returns (in naira) (EAB)	Standard Deviation (in Naira) (σ AB)	Coefficient of Variation (σ AB: EAB)	lower Bound (in Naira) (EAB- 2 σ AB)
	Forest crops (A)	Agricultural crops (B)				
I	0.0	1.0	2305.54	937.58	0.41	430.38
II	0.1	0.9	2206.65	858.93	0.40	488.79
III	0.2	0.8	2107.75	782.61	0.37	542.53
IV	0.3	0.7	2008.86	709.36	0.35	590.14
V	0.4	0.6	1909.97	640.24	0.34	629.49
VI	0.5	0.5	1811.08	576.74	0.32	657.60
VII	0.6	0.4	1712.19	520.92	0.30	670.35
VIII	0.7	0.3	1613.30	475.50	0.30	662.30
IX	0.8	0.2	1514.41	443.67	0.29	627.07
X	0.9	0.1	1415.52	428.48	0.30	558.56
XI	1.0	0.0	1316.63	431.68	0.33	453.27

NOTE: At combination level I, all the areas of the agroforestry farm is planted with agricultural crops. At level II, 10 percent of the agroforestry farm is planted to forest crops while 90 percent is plantyed to agricultural crops etc.

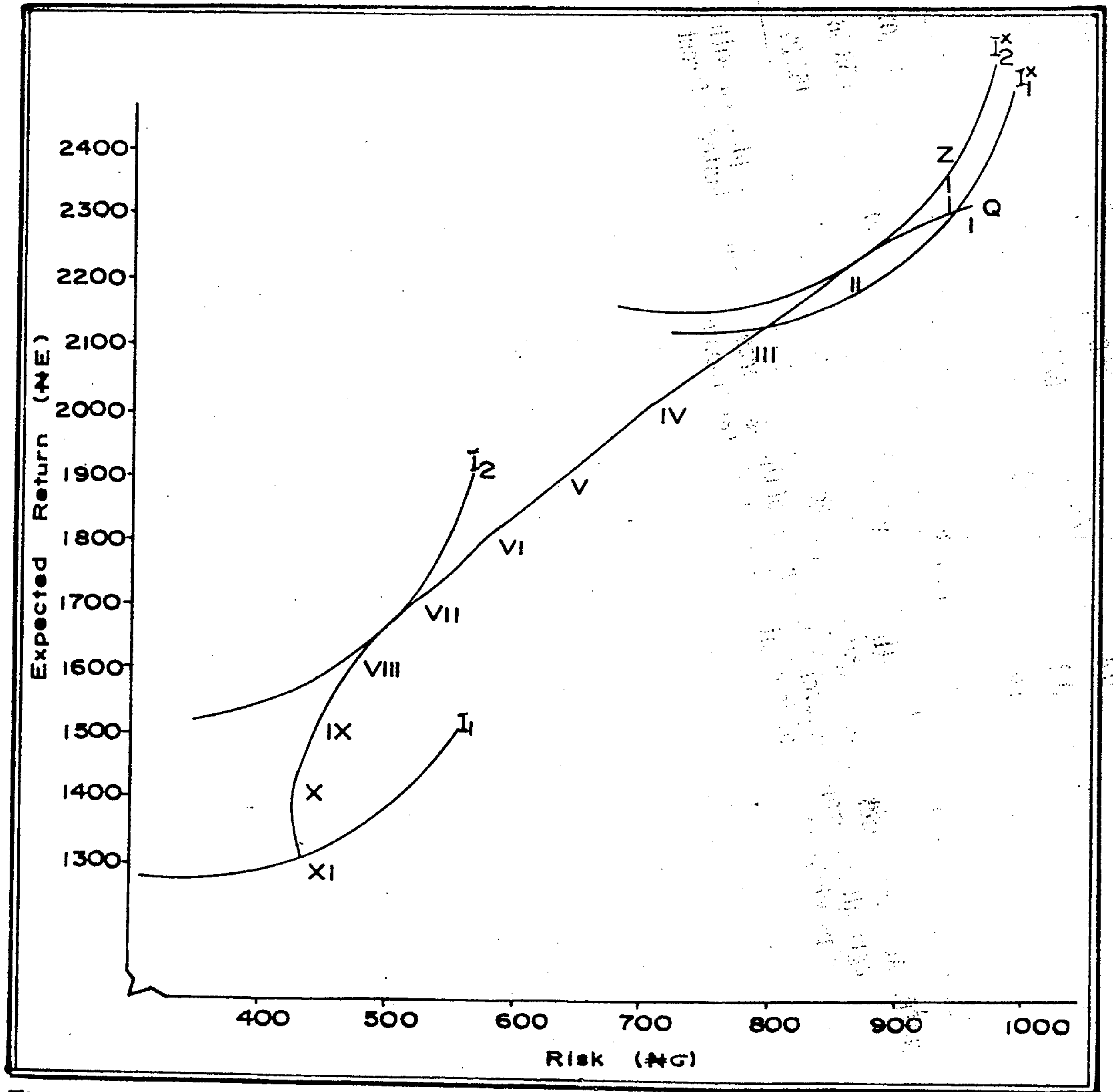

Figure 1: Risk management choices in traditional agroforestry.

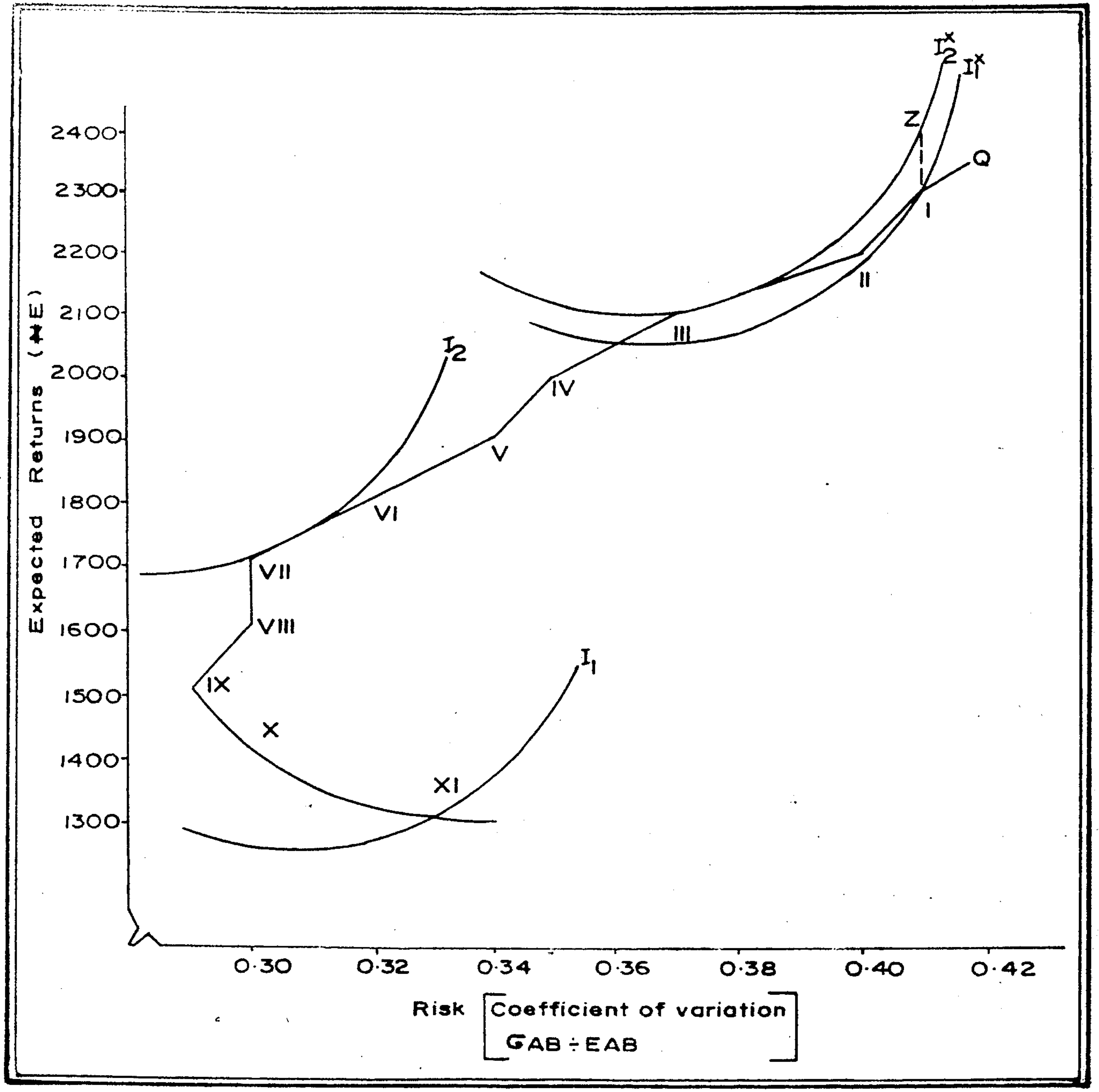

Figure [illegible]. Risk management choices in traditional agroforestry.

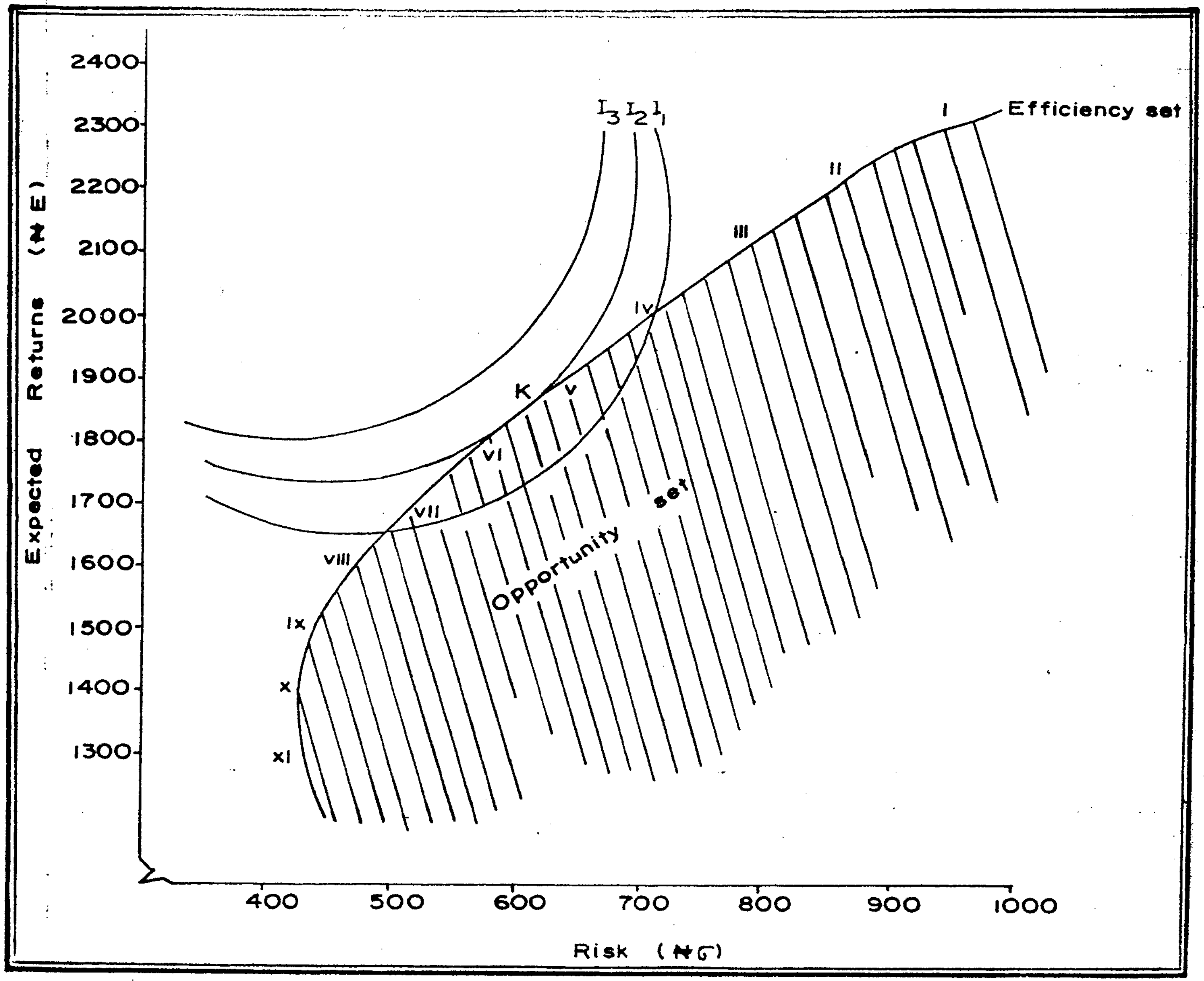

Figure 3. Selection of an optimal portfolio of risky assets.

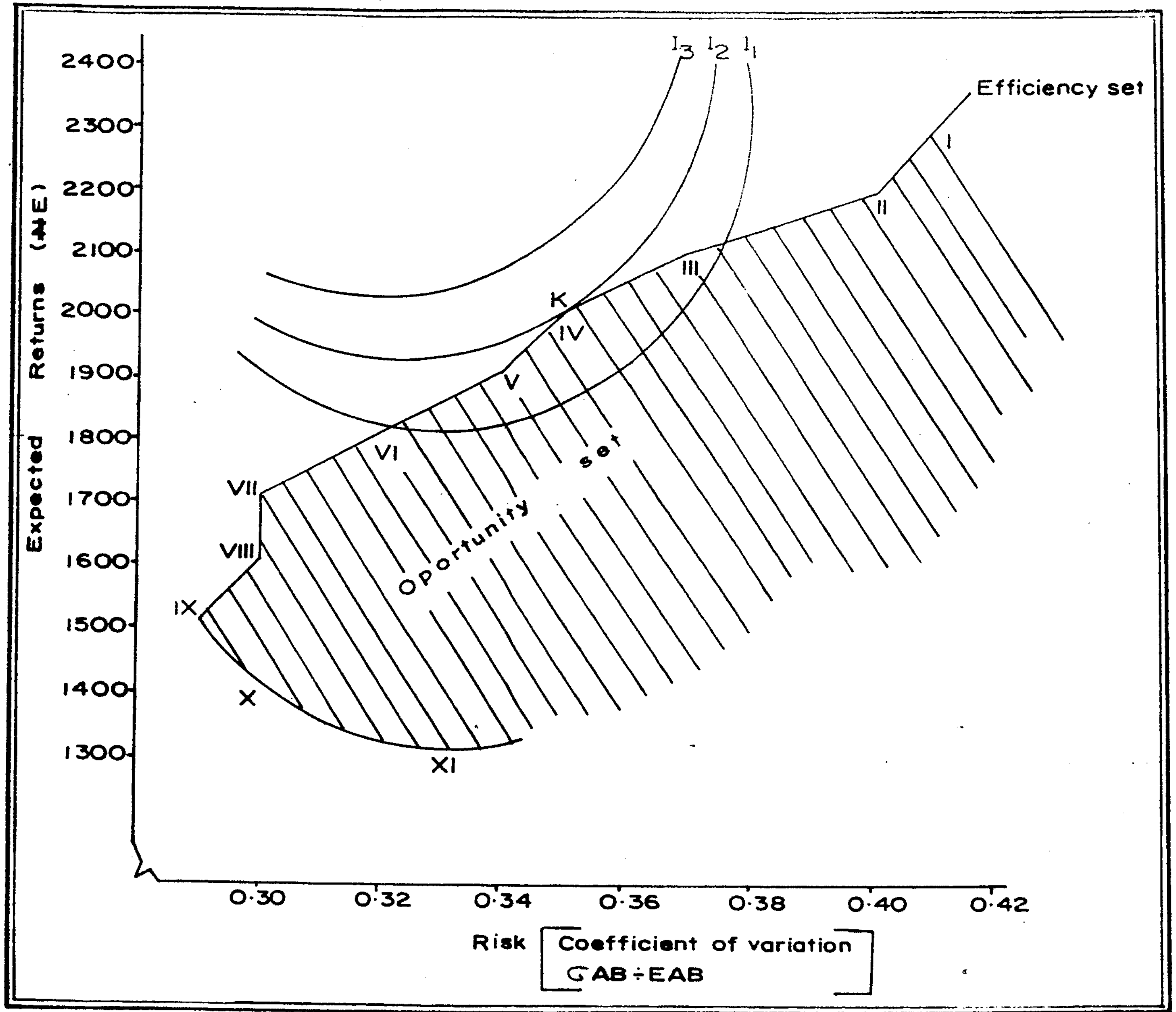

Figure 1. Selection of an optimal portfolio of risky assets.