Building the annual equivalent cost of perennial energy crops

Soldatos P.G.

in

Rozakis S. (ed.), Sourie J.-C. (ed.).
Comprehensive economic and spatial bio-energy modelling

Chania : CIHEAM / INRA
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 48

2002
pages 159-167

Building the annual equivalent cost of perennial energy crops

Peter G. Soldatos
Agricultural University of Athens, Department of Agribusiness Management, Greece

Abstract: Cost analysis of agricultural products is a delicate task because agricultural cost is very much site and weather dependent and because the required analytical data is not usually available due to the low organisational level of agricultural farms. In most cases, the researcher has to collect the required information on the spot and then record it and organise it before transforming it into useful cost information.

Although cost analysis is very important for managerial decision-making with regard to alternative uses of land and policy evaluation, there is a substantial lack of available systems for the transformation of collected data into useful cost accounting formats.

In this paper, a computerised system comparable with modern managerial accounting systems used for full costing has been proposed to record and synthesise detailed agricultural costing information in various standard formats. Some of the most controversial issues have been focused upon in an attempt to bridge the gap between cost analysis and investment appraisal.

Keywords: Cost analysis, computerised costing systems, profitability, investment appraisal, decision-making, giant reed, Greece.

Introduction

Cost analysis is used to identify and categorise all the elements that contribute to the full cost of the item analysed. Agricultural cost accounts usually differ from common company accounts both in structure and style (Ministry of Agriculture, Fisheries and Food, UK, 1998). This is probably due to the fact that part of the necessary information is not easily obtained or estimated. So, although in most cases the full cost is important for decision-making, published agricultural accounts do not usually analyse in detail the cost of unpaid items, such as labour and capital, because most of these expenses are not actually paid out to third parties, and therefore have to be imputed. In effect, the most common production costing formats record only *paid* expenses, (Kitsopanides, 1990; Kitsopanides *et al.*, 2000; Michalopoulos, 1989; Hilton, 1999; Drury, 1994).

The analysis of production costs is useful for two main reasons. (a) To report to third parties, such as tax authorities, shareholders etc, and (b) To provide management and decision-makers with the necessary information to manage the production unit profitably.

In order to serve the first purpose, a firm's cost information should be precise, regular and compliant with well-known and widely accepted financial principles in order to be easily comparable with information collected from other enterprises. It is obvious, however, that the need for compliance with established principles and common format reduces the flexibility of organisations to report in forms useful for managerial decision-making. Therefore, two different and usually not perfectly corresponding reporting and recording systems, co-exist in modern companies (usually identified as "Financial Accounting" -Accounting Departments- and "Managerial Accounting" –MIS-). The merits of "Financial" and "Managerial" reporting as described above are found in any accounting textbook (for example, see Drury, 1994).

In agriculture (Farm Accounting), the accounting and reporting systems are in general much less sophisticated than corresponding systems in other sectors having adapted to the limited availability of information.

Cost analysis of agricultural products is more delicate and cumbersome than that of industrial products, because agricultural cost is much more site specific and because vital cost information in agricultural farms and enterprises is not easily maintained due to smaller and less sophisticated production units. Besides, it has been found in many cases that at the farm level there is less need for formal reporting and that, at best, only paid expenses are recorded.

In addition, local land and labour markets are far from perfect and, as a result, opportunity costs are not easily identifiable. On many occasions, it happens that farmers are the owners of various factors of production, such as land and equipment, and that they also offer both their own and their family's labour to the farm.

Some popular profitability measures in agricultural accounting, such as farm income, are much easier to calculate and useful from a social or macro point of view, but their usefulness in managerial decision-making is very limited, since, for example, farm income depends on the size of the farmer's family and proportion of land ownership.

Full costing is required for optimal decision-making and profit maximisation. Indeed, it is necessary to identify and measure each cost item separately in order to be able to understand the cost structure in all its possible forms, e.g. distribution between fixed and variable, paid and imputed, and present it by activity, by factor of production etc.

The collection of agricultural information for cost analysis is usually conducted by public bodies on a regular basis, as well as by researchers on certain occasions. Therefore, the economist has to rely mainly on the first sources since the second is not always available for the crop or the region under examination. It has been found in many countries that governmental information on the cost of agricultural products has been grossly inaccurate, dated or non-existent. Furthermore, in most of these cases, such information includes only paid expenses and the cost centre is the "farm" and not the "crop" or "product", (Agricultural University of Athens, 2000).

In general, it seems that computerised costing systems that enable the researcher to fully analyse available or freshly collected cost information are lacking in the agricultural sector.

The approach proposed in this paper primarily leads to the "bottom line", but, nevertheless, maintains the necessary links with conventional agricultural cost accounting.

The model

The discussion is based on the *COSTOS* model[1], developed within the framework of an Altener project (see also Soldatos, 2000). The model is useful for the economic analysis of both food and non-food crops i.e. in cases where the opportunity cost of land is a significant parameter in the decision process and is measured by the profitability of already cultivated food crops.

The model measures the cost and profitability of crops and plantations at different geographical locations and under varying cultivation conditions. This is important for example in the examination of alternative land uses. With the help of the model, the profitability of existing plantations may be estimated and the profitability of alternative crops tested based on data from other areas with similar ground and climatic conditions.

COSTOS was developed in the form of a spreadsheet-based computer model capable of performing detailed cost analysis of the crop under examination after receiving the necessary information from the user. It is possible to link the model to external or internal databases to avoid tedious data input. The advantage of programming in a commonly available environment, such as MS Excel, allows users to modify and adapt the model to their own needs to a much greater extent than with more rigid models (e.g. *Beaver*, 1996).

[1] Multisees, Altener Project AL/98/227

The model features include the following:

- Easy perception of the interrelations of the magnitudes involved because of its open spreadsheet character.
- Convenient arrangement of input data and result tables that facilitate the user's understanding of the whole set-up.
- The user obtains the results in a format capable of further manipulation and exploitation.
- Both annual and multi-annual crops can be analysed using the model. Harvesting rotation can also be covered.
- Energy and labour needs are reported separately.
- The amounts of fertilisers and pesticides used can also be reported in a format useful for environmental analyses. For the same purpose, the amounts of various fuels used by agricultural machinery can be reported separately as well.
- The model performs cost analysis on a "per hectare basis" and is not concerned with the total cultivated area. Although this is handy in many respects, the user must have an idea about the actual size of the plantation in order to fill the input forms wisely.

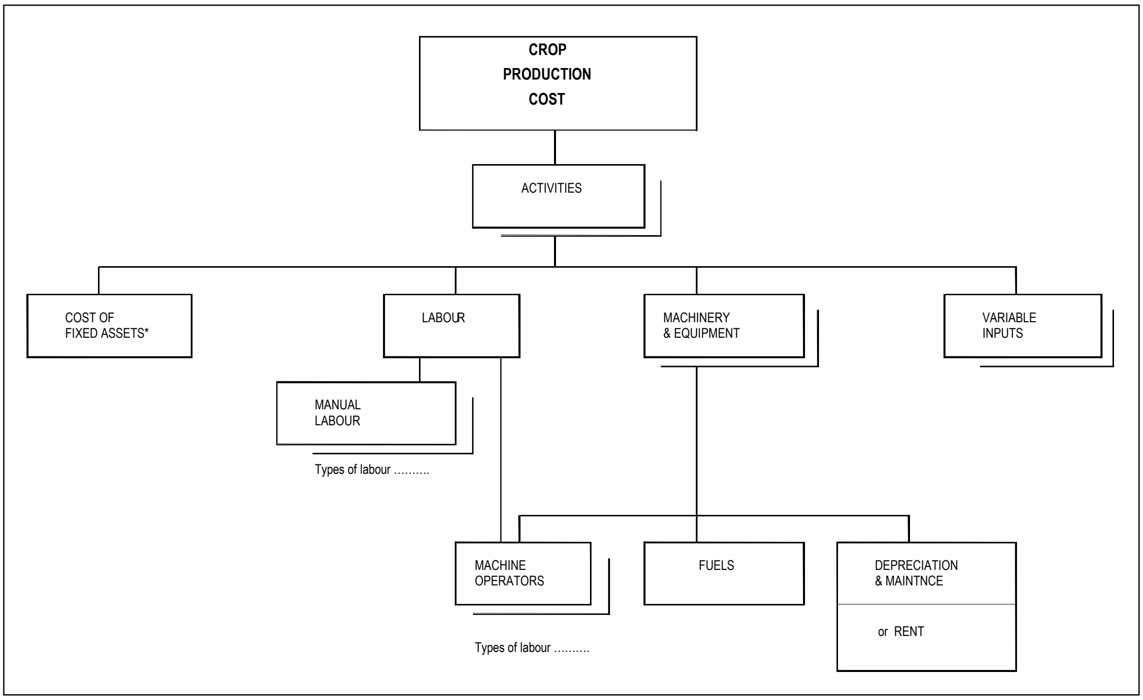

Figure 1. Structure of COSTOS spread

In most multi-annual crops, expenses do not necessarily occur regularly, i.e. annually. The same is true for harvesting which may not be annual or may start a few years after plantation, giving rise to irregular cash inflows. Therefore, costing should take into account a *typical* or *average* year in order to give a meaningful cost estimate. *COSTOS* goes a step further. It also measures the time value of money, i.e. it recognises that expenses during the early years of the plant are more important than expenses that have to be paid later in its life span and, therefore, it uses annual equivalent costs instead of simple averages. If there are two plants with equal average costs per unit of output, the model will take into account the timing of the corresponding expenses and reflect it in the total cost estimate, thus regarding as more costly the plant for which the bulk of the expenses appears in the first years of its life.

An analysis of production costs is important for decision-making, price setting, diagnosis of strengths and weaknesses, efficiency and profitability comparisons, sales promotion etc. For the production of agricultural products, for which yields and costs differ from place to place due to climatic and soil differences, a profitability and cost analysis mechanism is important because it is the basis of evaluation of alternative land uses. Such a mechanism is also useful when planning the production of crops for the first time in areas, which have never been cultivated before. The agronomist only needs to make a few fairly simple assumptions before obtaining a good estimate of the full cost and profit of the new crop.

Annual equivalent costs

It is only natural that the cost of agricultural products not only varies from place to place, but also from year to year mainly due to weather conditions. Therefore, if one needs to be precise, one should estimate product costs for each location and year separately.

However, for planning and decision-making purposes, this is not practical. Here, we need to calculate cost estimates that best represent the real average product costs. In order to maintain compatibility with investment appraisal methods, one should introduce the time value of money concept into cost and revenue calculations, assuming that early payments are dearer than late payments. This permits the replacement of a series of unequal payments with another equal-payment series, if and only if both have the same present value, (Bierman & Smidt, 1993).

For example, if a plantation has a lifespan of N=10 years and the cost of a special fertilisation procedure performed every other year is 100 € per application, then its annual equivalent cost including interest is (Cissell et al., 1986):

$P = PV / a_{N,\iota}$

Where

i= interest rate,

PV is the present value of the actual payments:

$PV = 100\,(1+i)^{-1} + 100\,(1+i)^{-3} + \ldots + 100\,(1+i)^{-9}$ and $a_{N,\iota} = (1/i)\,(1 - (1+i)^{-N})$

By applying the same time value transformation to all expense and revenue flows, one may calculate meaningful annual equivalent estimates of all costs and revenues that also give a truly representative annual equivalent net profit, which is now consistent with NPV recommendations.

Depreciation of multi-annual plantations

Multi-annual crops are assumed to mature some time (n years) after planting, remain at full growth for a number of years (N) and, at the end of their economic life, replaced. An approximation of their life cycle is shown in Figure 2.

The purchase and planting cost (C) of a multi-annual plantation is identified at point O, i.e. at the time of planting. If the expense is paid at different time intervals, it may easily be converted to its year-0 discounted equivalent by means of an interest rate (i) equal to the opportunity cost of capital.

Constant annual depreciation including interest of the amount C can be charged throughout the whole economic life (n+N) of the plant. This is equal to the annual payment of an equivalent annuity, i.e. an annuity with present value equal to C.

Alternatively, period OA may be regarded as the "investment period" and the cost of the plantation can be identified at the point of maturity (A) by compounding all incurred costs to this point. Installation costs in this case include not only the purchase and planting cost of the plantation, but also the cost of all other activities required until maturity, i.e. during the n years of period OA. In this case, depreciation of the plantation will extend over the shorter period AB (N years) during which the plantation is at full growth and, by assumption, fully productive (yield is assumed at OY for each year).

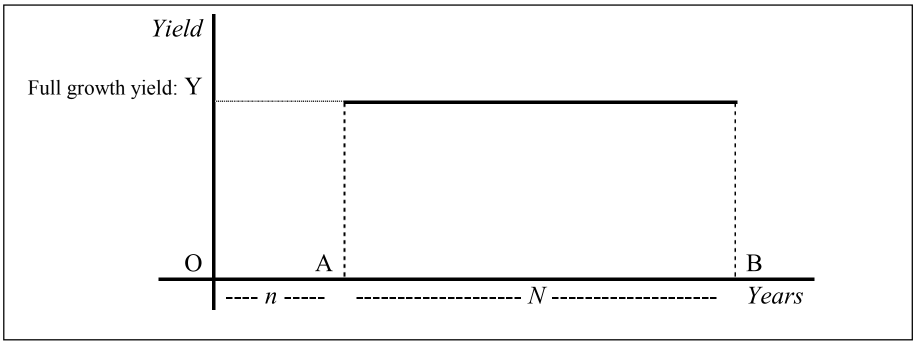

Figure 2. Production volume over the lifespan of perennial plantations.

This makes it easier to calculate smooth equivalent depreciation rates as follows:

(a) Estimate the plantation total investment cost (V) by compounding the plantation purchase cost C and the cost of all necessary activities performed during the first n years, (planting the trees, if not included in the purchase cost, initial and intermediate irrigation, fertilisation, etc.).

(b) Assuming zero terminal value of the plantation, the amount V will be fully depreciated during the period of N years that follow by annuity depreciation (Drury, 1992), with an annual depreciation amount (D) and interest (I) equal to:

$P = D+I = V / a_{N,i}$

Where: $a_{N,i} = (1/i) (1 - (1+i)^{-N})$

(c) By assuming e.g. straight line depreciation, the annual amount of depreciation is

$D= V/N$

and, consequently, the amount of (constant) annual interest will be:

$I= P-D= V / a_{N,i} - V/N$

Following the above steps, the plantation annual depreciation and interest on capital employed are both constant throughout the whole plant's lifespan, (Boelje and Eidman, 1984).

Depreciation of mechanical and other equipment

"Own" equipment is characterised by its purchase cost (C) and economic life (L), (i.e. the time-span after which the equipment is replaced for natural or technological reasons).

By assuming straight-line depreciation and zero terminal value, its annual depreciation (D) and interest (I) are found as before:

$P = D+I = C / a_{L,i}$

$D= C/L$

$I= P-D= C / a_{L,i} - C/L$

Where: $a_{L,i} = (1/i) (1 - (1+i)^{-L})$

Mechanical equipment also has an annual maintenance cost and, in most cases, labour and fuel costs as well. Once annual costs (depreciation, interest and maintenance) have been estimated, they may be divided into the number of operating hours per year to give the hourly cost of the equipment. To this, one may add the hourly labour and fuel costs (which may differ according to the activity performed) and estimate the total hourly cost of equipment, broken down to all its components, i.e. depreciation, interest maintenance, labour and fuel.

Activities not performed annually

Some activities may not be performed regularly and uniformly year after year. For example, the plantation may be harvested every other year, etc. Other activities may be performed for part of the time, but not throughout the whole lifespan of the plant, such as, for example, special fertilisation procedures carried out only in the first few years, etc.

For each of the aforementioned activities, an annual equivalent flow is calculated as follows:

(a) First calculate the Present Value of the irregular flow of the activity, and

(b) Calculate the annual equivalent flow

$F = PV / a_{N,\iota}$

where:

N= life time of the plantation,   i= interest rate and

$a_{N,\iota} = (1/i) (1 - (1+i)^{-N})$

Cost of labour and mechanical equipment

Given the hourly rate of labour and mechanical equipment (as suggested earlier), and given the amount of time that these resources require for each unit of land, each activity and each month, one may easily calculate the value of total monthly and yearly requirements of labour or machinery. The following table shows how *COSTOS* collects the necessary information for each labour and machinery type.

Tractor								hrs/ha
Activity	J	F	M	A	M	………	D	Y-TOT
:								
:								
Irrigation								
Fertilisation								
Pesticiding								
:								
:								
Activities Total								

Figure 3. Information input format for mashinery

The seasonality dimension has been proved very useful because it shows peak labour and machinery requirements, as well as peak energy consumption, CO_2 emissions, etc.

Subsidies

National or European Union subsidies and other similar transfer payments do exist for a good number of agricultural products. However, they have a temporary character, may easily be withdrawn or reduced, and do not reflect the true market power of the product. Besides, if introduced at the top lines of agricultural accounts (they are usually added to gross sales or output), although signifying the importance of external flows, they distort all indices that lie below, render almost worthless comparisons between competitive plants and tend to be handled by researchers as if they were the result of a competitive market.

Transfer payments such as subsidies should only be added at the bottom lines, i.e. after we have a clear and net picture of the real market position of the product under examination. The output tables of *COSTOS* reflect the above suggestions by placing subsidies after "Net Profit Before Subsidies".

Application: The cost of giant reed (arundo donax) in Greece[2]

Giant reed is a multi-annual crop native in south European countries. Its stems are thin and grow to a height of 4-5 metres. It has a useful economic life of about 15 years and may be harvested every year. In Greece it yields an annual average of 30 tons per ha, which may be sold at about 60 € per ton.

Giant reed is grown today in Greece as wind breaking fence and there is little use of it for other purposes. In the energy field it is being considered as a possible substitute for oil or coal in the energy generation sector.

Under the assumption that the farmer already owns a tractor and irrigation equipment, the required investment for the cultivation of giant reed consists of the cost of plantings (12,500 plantings x 0,10 € each) and the expense of all associated activities, the annual equivalent cost of which has been calculated by *COSTOS* as follows[3]:

Table 1. Annual equivalent of initial cost breakdown

Initial investment annual equiv. cost	€/ha
Herbiciding	1.83
Ploughing	2.84
Initial fertilisation	1.92
Disc harrowing	1.39
Planting, incl. cost of plantings	131.25
Initial irrigation	3.34
TOTAL	142.57

The cost of land (rent) required for the cultivation of giant reed is 600 €/ha. The plant may also be cultivated in less expensive land (non-irrigated), but yields are much lower.

During its life time giant reed needs very little attention. Practically, it only needs moderate amounts of fertilisation and irrigation. It is being harvested once a year and in order to be transported and sold it must be chipped. Collection of stems and chipping is by far the most costly activity in terms of labour, machinery and fuel. It has been assumed that the chipper is too expensive to be bought by a single farmer. Instead, it is hired at a price, which is about three

[2] See also Panoutsou et. al., 2000

[3] Based on user data such as: Tobacco planter rent =31 €/hr, tractor purchase cost =29,000 €, tractor average annual usage =1,500 hrs, tractor useful life =15 yrs, skilled labour =4.5 €/hr, price of diesel =0.80 €/lt, etc.

times higher than the equipment's depreciation. The same is true for the planter. The data for the cost of labour and machinery per hour of operation are as follows:

Table 2. Operation cost rates

Labour / Machinery	€/hr	
Skilled labour	4.50	
Field labour	2.00	
Tractor depreciation*	2.44	
Tobacco planter	31.00	(rent)
Chipper	12.00	(rent)

* Calculated by the model

Based on user data such as the above *COSTOS* is calculating a number of tables grouping costs by different criteria. The two layout examples that follow indicate that the cost of land is critical for the cultivation of giant reed and the major reason for the lack of profitability. Although initial investment is relatively high, its annual equivalent for the 15 years of the plant's useful life is a small percentage of total annual equivalent cost. Collection and chipping is the most costly annual activity accounting for almost 40% of total cost. This is due to the relatively high rental cost of the chipper (which does not include labour and fuel).

The usefulness of such cost analyses is that the decision maker may easily identify the most important cost items and the ones that could possibly be reduced by applying appropriate policies. For example, in the case of giant reed, it is obvious from the analysis that the producer should search for cheap land and examine the possibility of selling his product before chipping. He may also consider the case of non-irrigated, cheap land and try to analyse the low-cost low-yield scenario.

Table 3. Cost analysis by factor

Factor	€/ha/yr	€/ton	%
Land	600.00	20.00	33%
Labour	305.92	10.20	17%
Rental of equipment	251.38	8.38	14%
Depreciation of equipment*	197.54	6.58	10%
Depreciation of initial investment*	114.69	3.82	6%
Variable inputs	17.66	0.59	1%
Cost of capital	150.00	5.00	8%
Fuel	144.09	4.80	8%
Overheads	60.00	2.00	3%
TOTAL PRODUCTION COST	1,841.49	61.38	100%
SALES REVENUE	-1,800.00	60.00	
plus Subsidies			
NET PROFIT BEFORE TAX	-41.29	-1.38	

* Including interest

Table 4. Cost analysis by activity

Activity	€/ha/yr	€/ton	%
Fertilising	20.95	0.70	1.2%
Irrigation	128.14	4.27	7.0%
Harvesting	43.35	1.45	2.4%
Collection & Chipping	696.28	23.21	37.8%
Initial investment	142.57	4.75	8.0%
Other (incl. land rent)	810.20	27.01	44.0%
TOTAL PRODUCTION COST	1,841.49	61.38	100%
SALES REVENUE plus Subsidies	-1,800.00	60.00	
NET PROFIT BEFORE TAX	-41.29	-1.38	

Bibliography

[1] Agricultural University of Athens. (2000). RICA Office.

[2] *Beaver*, Models for the Economic Evaluation of Selected Biomass Cultivations as an Alternative Land Use in the EU. (1996). AIR3-CT93-0985.

[3] Bierman H. Jr., and Smidt S. (1993). *The Capital Budgeting Decision*, 8th Edition, Macmillan.

[4] Boelje Michael D., and Eidman Vernon R. (1984). *Farm Management,* John Willey & Sons, NY.

[5] Cissell R., Cissell H., and Flaspohler D. C. (1986). *Mathematics of Finance*, Seventh Edition, Houghton Mifflin.

[6] Dickerson B., Campsey B. J., and Brigham E. F. (1995). *Introduction to Financial Management*, Fourth Edition, the Dryden Press.

[7] Drury Colin. (1992). *Management and Cost Accounting*, Third Edition, Chapman & Hall.

[8] Drury Colin. (1994). *Costing: An introduction,* Second Edition, Chapman & Hall.

[9] Drury Colin. (2001). *Management Accounting for Business Decisions*, Second Edition, Thomson Learning.

[10] Gittinger Price J. (1982). *Economic Analysis of Agricultural Projects*, Second edition, Economic Development Institute, World Bank.

[11] Hilton R. W. (1999). *Managerial Accounting,* Fourth Edition, Irwin McGraw-Hill.

[12] Kitsopanides G. (1990). *Farm Economics,* Ed. P.Ziti, Thessaloniki.

[13] Kitsopanides G., Zioganas C., Soldatos P., Gabrielides S., and Vainas A. (2000). *Organisation and Management of Agricultural Enterprises, Pedagogiko Instituto.*

[14] Michalopoulos G. (1989). *Introduction to Agricultural Economics,* Agr. Univ. of Athens.

[15] Ministry of Agriculture, Fisheries and Food, UK. (1998). *Farm Incomes in the United Kingdom 1996/97,* The Stationary Office, London.

[16] Panoutsou C., Kipriotis E., Soldatos P. (2000). Estimation of crops breakeven *points in northern Greece,* 1st World Conference on Biomass for Energy and Industry, Sevilla, Spain, 5-9 June, pp. 463-466.

[17] Soldatos Peter G. (2000). Measures of Agricultural Profitability: The COSTOS model, 6th Conference of Agricultural Economics: "In search of the future of Greek Agriculture", Thessaloniki.