Estimating the opportunity costs of REDD+
A training manual

Version 1.3

Chapter 6. Profits and net benefits from land uses

Objectives

Show how to:

1. Develop an analytical framework to estimate the profits (net benefits) of land uses (forest, agriculture, ranching),
2. Estimate financial budgets of land uses,
3. Identify sources of cost and revenue information needed to calculate profits,
4. Develop multi-year profit analysis of land use trajectories,
5. Identify and critically review methodological and data assumptions.

Contents

1. Economic analysis has many terms and phrases that are commonly used (Box 6.1). For definitions, see Glossary in **Appendix A** .

Economist words		
Discount rate	*Rent*	*Capital*
Net present value	*Net returns*	*Accounting stance*
Profit	*Enterprise budget*	

2. Avoiding deforestation often requires giving up the profits and employment opportunities that new land uses would have provided. Reforesting lands may also reduce profits and jobs. To know what participating in carbon funds and markets will cost, we need answers to questions such as:

- *What profits and jobs are generated by forests?*
- *When forests are cut, what do other land uses generate in terms of profit and employment levels?*
- *When forests are re-established what profits and jobs do they produce?*
- *What profits and jobs are associated with non-forested lands before af(re)forestation?*

3. This chapter shows how to estimate two important economic components of opportunity costs: profits and employment. Both profits and labor earnings from forests and other land uses are needed in order to estimate REDD+ opportunity costs. The procedures presented below are based on a bottom-up approach of data collection with analysis of revenues and costs for a wide range of land use activities.[48]

Box 6.1. Profit is about more than just money

We use the term *profits* as a convenient shorthand. Other terms, such as *net benefits, net revenues* or *net returns* could be also used. *Profit* is a concise and convenient way to describe the concept of benefits minus costs.

It is also important to note that especially in rural regions, the value of production is not always based on money. Many products and services have value despite not being purchased or sold (e.g., family labor inputs, household consumption of harvests, etc.). Imputing, or estimating, the value of these non-market goods and services is a challenge facing REDD+ opportunity cost analysis. (Other off-site non-market ecosystem services, such as watershed function and biodiversity co-benefits, are addressed in Chapter 8.) Thus *profit* is used in this manual to represent the general concept of net benefits that land users receive from a given land use.

[48] Other less-precise REDD+ opportunity cost approaches are described in the introduction, Chapter 1.

Why such detail?

4. The bottom-up approach provides a rigorous and transparent record of the data collected and its analysis, along with a review of methodological assumptions, that are essential for accurately estimating REDD+ opportunity costs. When coupled with carbon stock information, the profit analysis of land uses will enable policymakers to estimate REDD+ opportunity costs.

5. This chapter helps develop capacities to:

1) systematically estimate and compare profits generated from different land uses,
2) identify data required for analyses, and
3) estimate profits according to a three-level hierarchy of activities within land uses:
    a) *enterprise (or activity) budget*, the basic building block of information per activity,
    b) *land use system budgets* account for the multiple enterprises found within land uses,
    c) *budgets of land use trajectories* represent how a land parcel may undergo numerous land use changes.

Upfront issues – clarifying assumptions

6. Many types of data and procedures are needed to estimate the profitability of land uses. Here are some details worth mentioning now.

Whose perspective? (the accounting stance)

7. REDD+ programs involve different types of landowners. Such owners can be a country or from an individual group (e.g., farmer, rancher, logging company, community). The way costs and revenues are calculated – called an accounting stance – represents the viewpoint of individual groups[49] or the country.[50] Although an accounting stance does not affect productivity data (e.g., yield/harvest quantities), the difference in perspective determines the data collected, prices and discount rates within budget accounts, and thus profit analyses. Inappropriate mixing of data and methods is a common and potentially easy error, and can result in misleading estimates (Pagiola and Bosquet, 2009).

8. For the accounting stance of a country, costs and benefits should be valued at the social value of resources (i.e., their value in their next-best alternative use) rather than

[49] Often termed *private* or *financial* profitability.
[50] Often called *social* or *economic* profitability.

observed market prices. The social value of a resource may differ from that observed in markets because of either policy distortions (e.g., taxes, subsidies, import restrictions, etc.), or market imperfections[51] (e.g., from a lack of property rights). In contrast, costs to individual groups are valued at actual prices, including any taxes (Pagiola and Bosquet, 2009).

9. Discount rates, and how they are affected by accounting stance, are discussed below.

Which actual price to use?

10. Actual prices can differ, often substantially, according to location: farmgate, local market, national market and international market. Because of transportation and intermediary costs (e.g., of merchants/middlemen), farm gate prices can be 20-95% of a national or international market price. Analysts often use the following three types of price data, which represent different stages of a product within a product value chain:

- *Farmgate price:* the price a farmer receives for outputs or pays for inputs at the boundary of the farm. These prices are determined from field surveys with farmers or found in agricultural census data.
- *Wholesale or sub-national market price:* the price at which agricultural products are traded on various domestic markets. These prices include the cost of transportation between farm and market, and are available from surveys at market locations.
- *Border price:* the price at which agricultural goods are exported from the country. Such prices are available typically through official statistics.

11. The recommendation is to use farmgate prices to represent the actual costs on a particular land use. Adjustments are needed when farmgate prices are expected to differ from prices from where data are collected (e.g., local markets). Local agronomists and extensionists often know farmgate prices. Where not, an adjustment factor can be estimated – often related to distance to market and quality of road and river transportation.

How to deal with prices distorted by policies?

12. Prices can also differ due to government market interventions. Inputs subsidies (of e.g., agrochemicals, gasoline, fertilizers) can increase profitability; whereas input taxes can reduce profits. Similarly, profitability of farm and forest land use is decreased by export taxes which typically affect farmgate prices. Output subsidies or import taxes and quotas increase prices and profitability.[52]

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[51] A situation in which the market does not allocate resources efficiently. Market imperfections can occur for one of three reasons: (1) monopoly - when one party has power that can prevent efficient transactions from occurring. (2) a transaction has externalities (side effects) that reduce efficiency elsewhere in the market or the broader economy, and (3) nature of certain goods or services (e.g., public goods such as roads).

[52] In some countries, cattle production and oil palm are land uses, for example, that have received subsidies.

13. Despite all these potential distortions to prices, governments are intervening less in markets than before. To enhance global competitiveness and fair trade, international agreements on tariffs and trade typically limit the use of such mechanisms. In addition, governments often have less financial capability to subsidize economic sectors as budget overspending and debt is being controlled by lending organizations (e.g., banks, International Monetary Fund, etc.).

14. If such price distortions are apparent and important, the recommendation is to have separate estimates for (1) costs to land users and budgetary costs to the government (using unadjusted prices), and (2) costs to the country (using prices that correct for distortions). A Policy Analysis Matrix (PAM) can used to compare of the results different accounting approaches (or methodological assumptions) of economic analysis. For example, differences in agricultural and natural resource policies and factor market imperfections can contrasted with budgets calculated at private and social prices (Monke and Pearson 1989 is the basic reference).

Why use a discount rate?

15. A discount rate is the way economists account for time while estimating the value of goods and services. For profit analyses that examine multiple years, the value of future profits must be properly discounted. Simply put, a dollar today is worth more than a dollar tomorrow.

16. The discount rate to assess costs to the country should be the social discount rate normally used by the government. In contrast, the discount rate to estimate the costs and benefits to individual groups should reflect their rate of time preference. If the costs to all individual groups (including the government) were added up and re-calculated based on social value of resources rather than observed prices, they should equal the costs to the country. In other words, the costs to the government and the individual groups determines the overall costs to the country.

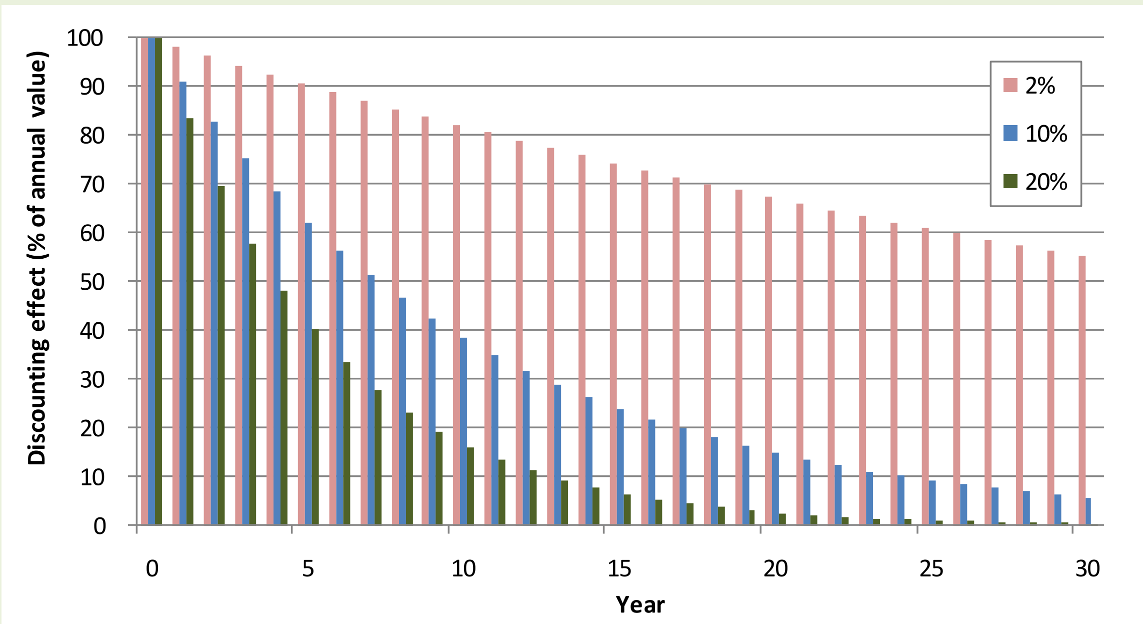
17. From a national perspective, the discount rate can be equated to the cost of borrowing money. The interest rate on loans (often between 5 and 10% annually) is a useful proxy. From an individual perspective, the costs of borrowing money are typically much higher. Interest rates in countries often range between 10 and 30% per year, or higher, if loans are available. For the purposes of opportunity cost analysis, the real interest rate should be used. How to deal with inflation is discussed below.

Box 6.2. Understanding the potentially big effect of discount rates

In many developing countries, interest rates are high, reflecting perhaps unstable economic conditions or the inherent risk of loans not being repaid. Nevertheless, strong criticism arises from employing the use of high discount rates. Within a NPV analysis, the chosen discount rate can have strong effects. This is a result of compounding, where the discounting includes the cumulative effect of all previous years. For example, at a 10% discount rate, NPV of profits at the end of the first year (t=1) are valued 9.09% less. At the end of year 2, the profits are valued 17.4% less. In other words, to account for the time value of money, the profits would need to increase by these discounted amounts in order for the future profits to be of the same value.

When a discount rate is applied over a long time horizon (15+ years), the NPV profits in the final years can be dramatically lower. The effects a 2, 5, 10, 15 and 20% discount rate are depicted below. At a 2% discount rate, the NPV profits in year 20 “lose” over 32% of their value (nearly 45% at year 30). At a 5% discount rate, the NPV profits in year 20 “lose” over 62% of their value (nearly 77% at year 30).

At higher discount rates, the effects are more severe. Use of a 15% discount rate implies that the NPV profit in year 20 have lost 93% of their value (in year 30, over 98%). With 20% discount rate, the year 20 NPV profit is down approximately 97% (in year 30, down over 99%).



Effect of discounting on future values (2, 10, 20%)

Source: Authors.

How to estimate unstable and non-existent prices?

How to value inputs provided and outputs consumed by the household?

18. Especially with smallholder farms, labor inputs or inputs retained from previous harvests (e.g., seeds, manure, etc.) are often used within a farm and are not purchased. Therefore, the prices of such inputs may not be readily available. Smallholder farm households also may consume much of their harvests instead of selling them. Such

subsistence or semi-subsistence agriculture is common in many rural regions. While the earnings are not realized, the value of the output should be recognized at its market price.

19. In addition, some farm inputs may have multiple possible prices (e.g., seeds retained from harvest could be valued at the forgone income at time of harvest, or the cost at time of planting). It is recommended to use the cost that farmers actually incur for such inputs. In the case of seed, the cost of storing seed may be minimal, therefore the seed should be valued at the time of harvest.

20. Although such non-market inputs can be valued in different ways, be done justifiably, and produce different results, it is important to document the assumptions and methods. Sensitivity analysis of the assumptions can be conducted to see the impact of an assumption upon results of the analysis. With such an analysis and review, the difference may turn out to be rather either insignificant or worthy of discussion amongst peers to decide the best, most relevant, option.

How to handle prices and yields that are highly variable over time?

21. Agricultural production and product prices can be notoriously unstable. When collecting data at one point in time, it is likely that the information is not representative of yields and prices over a span of many years. Two basic types of variation exist (and their causes):

1. Prices and yields vary around a static mean (e.g., because of variable weather conditions, pest and disease outbreaks, exchange rate fluctuations), and
2. Prices and yields vary around a changing (trending) mean (e.g., mean yields decline because of soil degradation; real prices trend up because of increased consumer demand, energy costs; prices trend down because of demand shifts away for particular commodities or increasing supply associated with productivity growth).

22. It is therefore recommended that price information be examined over multiple years and the context of agricultural productivity and markets be examined. Past trends can provide us with important information on how parameters of profitability analyses may develop in future years. For example, yields and input use of agricultural enterprises often increase gradually over time as technology improves. Meanwhile, yields can decrease resulting from soil degradation.

23. Prices may also be subject to both positive and negative trends depending on population and economic growth at local, national, and global levels. While trends do not usually increase uncertainty, they can nevertheless lead to significant biases in opportunity cost estimations, especially if longer time REDD+ contracts are at stake. If there is reasonable evidence to expect major trends in key enterprise budget items, these items need to be adjusted accordingly for each year within the planning horizon. A gradual adoption of pest resistant corn varieties, for example, can be introduced in the analysis by

slowly increasing yields and reducing pesticide expenses in the corn enterprise budget according to the expected trends in these parameters. Uncertainty and associated risk of parameter estimates can by analyzed using stochastic analysis (Box 6.4).

Box 6.3. Risk and uncertainty analysis

Numerous computer programs are available to analyze the effects of risk and uncertainty (e.g., @Risk, Quametec, etc.). Using stochastic analysis methods within an Microsoft Excel spreadsheet, the programs can reveal the likelihood of a particular outcome given uncertainty of multiple parameter. Such analyses help decision makers to better understand the potential implications of interventions within uncertain environments.

24. All parameters used in profitability analysis are subject to uncertainty as a result of data collection and processing errors. District averages of yields, for example, often overestimate actual yields (aggregation bias[53]), and information from field surveys may be subject to recall biases. In addition, survey respondents tend to generalize based on recent year experiences. To aid practitioners in understanding the process of assembling land use budgets, the accompanying spreadsheet workbook contains numerous notes. Sensitivity analysis of results can help analysts identify the most reasonable assumptions.

Profits are calculated in terms of what?

25. Profits can be measured in terms of time (e.g., workday or salary) or in terms of returns to land (i.e. $/ha). Within REDD+ opportunity analysis, returns to land typically makes most sense. Moreover, it is a common measure understood by many.

Should the cost of land be included in calculations?

26. Including land costs in the analysis only makes sense from the perspective of an investor who is considering acquiring land (through purchase or rental) to undertake an activity. For a farmer or logging company that already owns/controls the land, the analysis considers the returns to the next-best land use alternative. Therefore, the opportunity cost of land is already being taken into consideration. In other words, since the profitability of activity A to activity B is being compared, it makes little sense to include costs of land in profitability estimates, since the costs cancel out. For example, investments to improve profitability, and the value of land, are accounted for within a multi-year analysis.

And labor?

27. A more difficult question is whether profitability should be estimated in terms of returns to labor (i.e. $/workday). For many smallholder farm households, it could make

[53] Resulting from assuming relationships observed for groups necessarily hold for individuals. For forest margin areas, lower yields can be masked if average values include areas with higher inputs and productivity.

more sense to express results both in terms of return to land and family labor. Especially in forest frontier regions, labor and capital are limiting factors of production. Since land is relatively abundant, smallholder farmers most carefully allocate their scarce labor resources (along with their land and capital resources).

28. Opportunity costs of REDD are nevertheless calculated in terms land. Fortunately, it is possible to impute the value of family labor in the farm activity costs, thus giving profitability in terms of returns to land. Since family labor can be reallocated to other uses if a different land use is chosen, the returns to land can be a relevant measure of the opportunity cost of land use change.

29. From the perspective of an individual, household income from a given land use is a relevant measure. This includes both profits and the implicit wage of their labor. REDD+ opportunity costs need to account for both the profits and implicit wages. Both types of earnings are forgone with REDD+.

Which profits from a land use should be analyzed?

30. A profitability analysis starts with developing detailed budgets of simple activities (also called enterprises) within land uses. These budgets are a summary of cost and revenue information. Enterprise budgets typically describe the activities that occur within a planting and harvest season. Examples of enterprises include NTFP collection, timber harvesting, and annual crops. Enterprise budgets of multi-year crops (e.g., cassava), animal production, perennial tree crops (e.g., cocoa, oilpalm, coffee, etc.) require accounting of multiple years that represent all phases of an enterprise: preparation/investment, maintenance, harvest and post-harvest activities on-farm. Enterprise budgets are an important building block to represent land uses and land use trajectories.

31. Budgets of land use systems can account for a combination of activities, such as agricultural and tree crops. These budgets are also multiple year summaries representing all phases of an activity: preparation, maintenance, harvest and, perhaps, fallow periods.

32. A budget of a land use trajectory is a longer-term summary of land uses and land use changes. Land use trajectories are developed as a basis for REDD+ opportunity cost estimates and analysis. Table 6.1 summarizes the three types of budgets and associated sources of information.

Table 6.1. Types of budgets

Type of budget	Description	Data sources
1. Land activity/ enterprise	A single year summary of costs and revenues from a single activity. *Forest conversion, forest harvests, agriculture & ranching activities within land use changes*	Local experts
2. Land use system	A multi-year summary of a single enterprise or linked enterprises of a land use *Land use change cycles and transitions*	Local experts
3. Land use trajectory	A summary of different land uses starting from current use. The basis for opportunity cost estimates.	Local experts, literature, remote sensing

Source: Authors

33. With land use trajectories, a profitability analysis often represents different groups or individuals who are responsible for different portions of the trajectory. For example, logging companies for forest degradation, settlers for deforestation and slash-and-burn agriculture. Although these changes make no difference to an analysis from the country's perspective, it can be very important when the analysis is from the perspective of an individual group. Adequate and proper compensation for REDD+ depends on such knowledge of land use changes.

What to do when profits differ across sub-national regions?

34. The distribution of profits for a particular land use within a country can be highly variable. Consider cocoa land uses, a principal driver of deforestation and degradation that occupies more than 8 million ha in the Guinea rainforests of West Africa, coastal Atlantic rainforests of Brazil, rainforests on the Indonesian island of Sulawesi, and other areas.

35. Wide differences exist between the harvest yields of cocoa producers (Figure 6.1). In Ghana, the distribution of yields from nearly 5,000 producers show that the mean is more than 100 kg/ha greater than the median. Causes include significant differences fertilizer uses, and management practices. Thus although cocoa systems can be considered a land use system within an opportunity cost analysis, examination of yields and causes of differences is essential to improve the accuracy and precision of profit estimates.

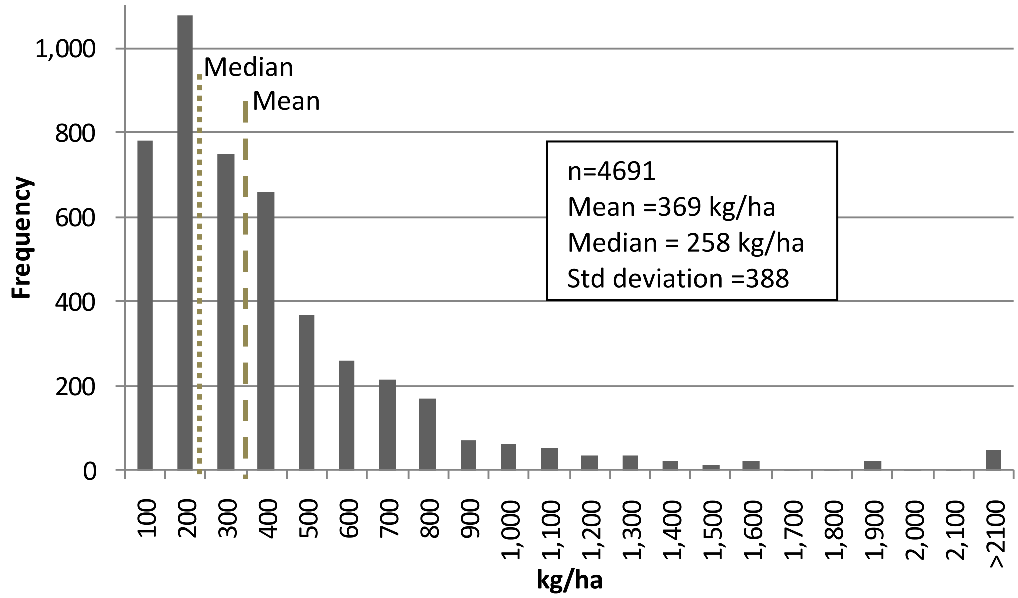


Figure 6.1. Cocoa: harvest yields per ha, Ghana

Source: 2001/2 Sustainable Tree Crops Program, baseline survey (IITA, unpublished data).

36. Within the forest sector, timber prices and previous harvests often affect forest profit levels (and opportunity costs). In Brazil, for example, large amounts of timber have been harvested. Figure 6.1 is a provincial scale map of a forest logging history.

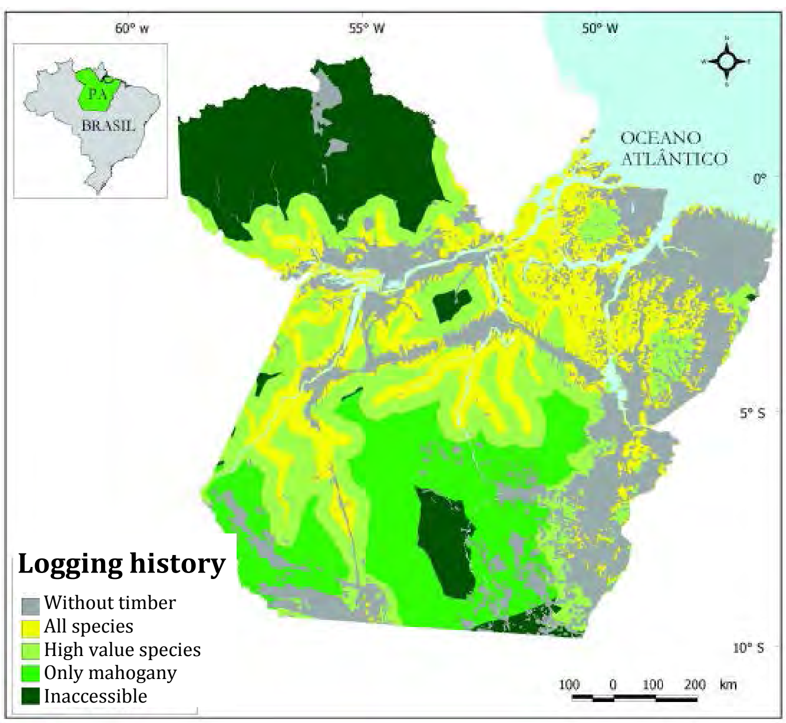


Figure 6.2. A geographic assessment of logging history (Para, Brazil)

Source: Souza Jr, et al. 2000.

37. Although a forest inventory provides an assessment of available timber and timber already harvested, analysis of current and future logging activities can be conducted per geographic region, thereby revealing profit potentials. Within Para, four areas of logging activity have been identified: Central, Estuarine, East and West (Figure 6.2).

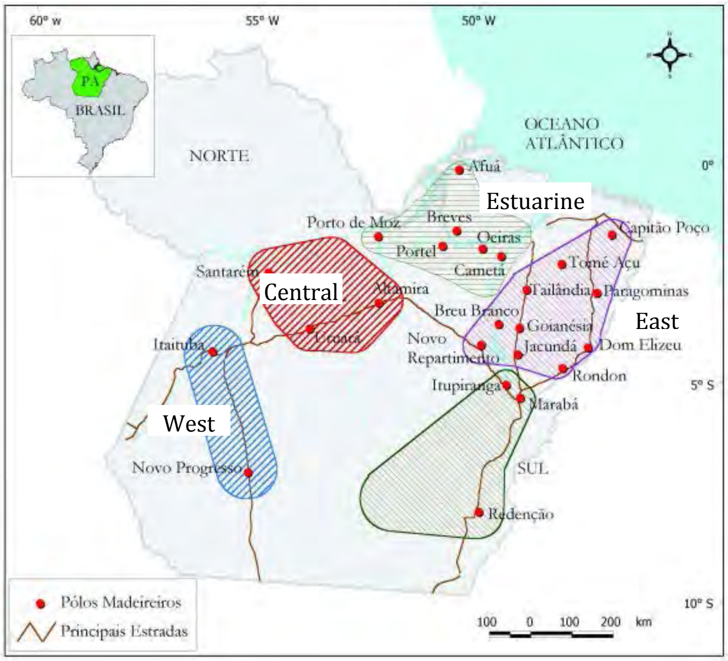


Figure 6.3 Logging regions within Para, Brazil.

Source: Verissimo, et al. 2002.

38. The location of a logging operation affects not only the amount and quality of available timber but also prices received. The figure below shows how timber quality of estuarine regions are of overall lower quality. The western region contains a higher percent of high and medium quality timber.

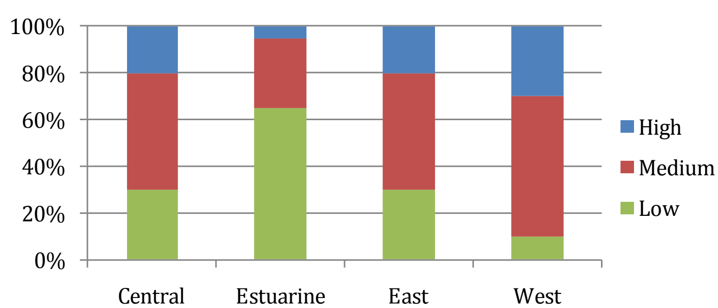


Figure 6.4 Regional estimates of timber quality (% timber; Brazil, 1998)

Source: Verissimo, et al. 2002.

39. Prices received for timber differ per quality category and, to a lesser extent, logging region. The price differential between high and medium quality is significantly greater than the difference between medium and low quality timber. The price of high value timber is approximately 2½ times more than prices of medium and low quality timber.

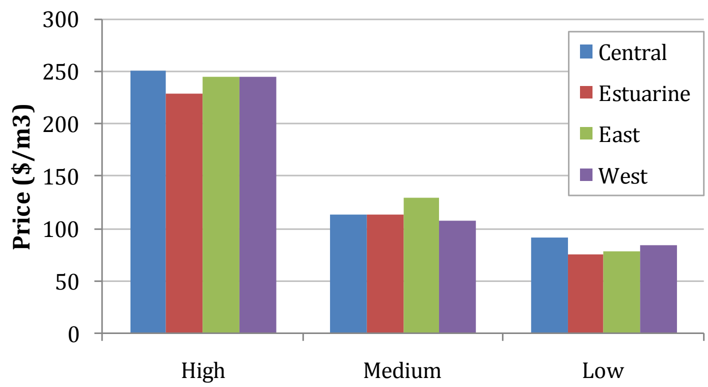


Figure 6.5 Price of sawn timber per region and quality grade (US$/m^3; Brazil, 2001)
Source: Verissimo, et al. 2002.

40. Therefore, at a national level, different budgets should be developed to adequately represent the differences within land use systems.

Enterprise budgets

Components and construction

Enterprise budgets estimate profit (Π) in local currency per hectare ($/ha):

$$\Pi = pq - c$$

Where: p = price ($/ton), q = yield (ton/ha), and c = costs ($/ha)

41. Revenues (*pq*) come from the output (e.g., crop, animals, timber) of a land use activity. Costs (*c*) arise from the use of two types of inputs: physical (or capital) and labor. These measures serve as adjustable parameters for subsequent scenario, sensitivity and tradeoff analyses.[54] A sample enterprise budget is presented in Table 6.2. For more detail on enterprise budgets, see Gittinger (1982).

[54] A parameter is a specific value of variable estimated or selected (e.g., mean, median) within an analysis.

42. *Physical inputs* include seeds, fertilizers and chemicals, which are typically used annually. Longer-term investments such as fences, tools, machinery, animals (cattle), etc. are also physical inputs.

43. *Labor* inputs can be estimated using wage rates. Two types of rate, however, are typical: legal minimum wage and actual wage. Nationally-established minimum wages may include social benefits: health and pension. In contrast, actual wages are often significantly lower, especially in remote forest frontier areas. Actual wages should be used. Effects of different wage rates on opportunity cost estimates can be examined with sensitivity analyses.

44. A monthly labor calendar is helpful to identify, discuss and quantify workday activities in order to estimate total labor input. Labor activity may be valued at a single wage or a different wage rate, depending on skills required or scarcity of seasonal labor. The first task of the agricultural/logging season, typically land preparation, should determine the starting month of the calendar. The labor calendar can be differentiated between hired and family labor, and also by gender. This enables analysts to examine the potential social effects of REDD+ policies.

Table 6.2. A sample enterprise budget

Rice *(per hectare)*	
Profit	
Total Input Costs	

Total Revenues	
Harvest	*Price*

Product	*Quantity*	*Price*	***Cost***	*Units*
Seed Fertilizer Machinery Tools				

Labor Activity	*Workdays*	*Wage*	
Preparation Planting Weeding Harvest Threshing Transport			

Calendar: Workdays

Activity	***Jan***	***Feb***	***Mar***	***Apr***	***May***	***Jun***	***Jul***	***Aug***	***Sep***	***Oct***	***Nov***	***Dec***	***Total***
Preparation Planting Weeding Harvest Post-harv. process Transport													
Total													

45. Careful consideration of the units of analysis within budgets is essential. Units of measure, such as kg, liters, tons, should be noted. Local measurement units of land area and harvest weights can be used in order to facilitate discussion with farmers. Conversion to metric measures (e.g., hectares, kilograms), however, are needed to enable a standardized analysis.

46. While yields can be converted to required per hectare units, cost information may come in different units, e.g., workdays per ton of product harvested and thus require conversion to a land-based measure. If farm inputs are used for more than one enterprise, the cost of input should be shared and attributed to the other enterprises. For example, rental rates per hectare or day are convenient approximations for the use cost of tools and machinery (e.g., chain saws, machetes, machinery, etc.). Alternatively, prices and average lifetime values can be estimated to impute annual use cost per hectare.

47. Numerous methodological and data assumptions underlie the information within enterprise budgets. Parameters (e.g., of inputs, harvest yields and prices) can easily be adjusted to represent specific locations and contexts. Consequently, notes regarding contexts and assumptions are helpful to understand the accuracy and assure the relevance of budget information.

Data collection

48. The data needed to develop enterprise budgets can come from a variety of sources. Since budget information is basic to analyses of agriculture, ranching and logging activities, national research centers and universities may have budgets already available. If not, production data can be collected via interviews with farmers, or other experts (e.g., agronomists, extensionists, foresters) and via literature review of case study analyses of production systems.

49. Detailed secondary information on inputs (e.g., workdays, prices) is rarely readily available. Essential to estimating costs, accurate data on enterprise inputs is best obtained via farmer and key informant interviews. Given budgetary or time restrictions, precise measures for some items within an enterprise budget may not possible. In order to quickly advance analyses, estimated measures can be used, based on expert opinion and other sources. In addition, information from other budgets and studies can be used in an IPCC Tier 1 or Tier 2 manner and adjusted to local conditions.

50. Budgets should be developed in local domestic currency. As estimates in domestic currency are typically less vulnerable to exchange rate fluctuations,[55] any database should be expressed and maintained in domestic currency. Conversion to foreign currency can be accomplished for specific purposes when needed. For example, at some later point

[55] Prices of internationally-traded commodities such as cocoa or palm oil, may be less volatile.

countries will need to know how their REDD+ opportunity costs compare to possible REDD+ payments, which will be stated in US$/$tCO_{2e}$ or other such terms. For this particular purpose, countries will need to convert results to US$ or €.

51. Budgets collected through field surveys can avoid most of these problems but are much more expensive to collect. The accuracy and reliability of budgets also depends on appropriate sample design and enumerators being well-trained. Pre-testing of questionnaires with focus groups along with a review and critique of responses can help assure the collection of all needed information. Where areas are relatively homogeneous, focus group interactions instead of wide-scale surveys can provide better information. Focus groups permit the acquistion of in-depth information and beneficial dialogue in comparison with surveys, which typically extract rather repeative basic information.

52. It is important to note that budgets developed through interviews can only obtain reliable data for the current and recent years. Data obtained while attempting to remember earlier years can be very inaccurate. In addition, when yields and prices are very variable, official budgets can also be very unreliable. Therefore, comparison and discussion of official government information, farmer responses and expert opinion are helpful to identify the most appropriate budgetary information.

53. Interviews are difficult when the activities concerned are illegal (e.g., logging, bushmeat trade, coca production). By enhancing trust and assuring anonymity of responses, required information can often be obtained. Working through social networks of families, friends and co-worker can also facilitate the data collection process.

54. Table 6.3 summarizes the advantages and disadvantages of different data collection approaches. For details on data collection methods, see Holmes, et al. (1999), FAO (2001, 2002), and Pokorny and Steinbrenner (2005).

Table 6.3. Advantages and disadvantages of data collection approaches

Method	Advantages	Disadvantages
Survey (in-person)	-Expert-based -Timely -Comprehensive, large sample size can increase statistical significance of results.	-Follow-up questions require second communication -Expensive for large sample -Proper training of interviewers/ enumerators essential.
Case Study	-Close discussion with land user -Broader questions -In-depth questions and answers possible.	-Dependence on secondary information and knowledge by personnel -Limited representativity.
Experiment station	-Control over data quality -Allows for the testing of alternate scenarios and ideas.	-Higher yields than field conditions - Limited validity of extrapolation -Specific individual results
Existing sources	-Cheap to collect -Data already processed.	-Results may not contain information needed -Results may reflect "average" conditions that do not represent any actual farmer -Information may be out-of-date -Results may be of "best case" yields, especially for crops of interest to the ministry/project, and rarely achieved in practice, -Results show input use that reflects recommended rather than actual practice, -Methods use official rather than observed prices, -Methods may be based on hidden assumptions.

Adapted from: Pokorny and Steinbrenner (2005);Pagiola (personal communication, 2010).

55. Given the challenges mentioned above, many estimates within enterprise budgets will likely be imperfect. A systematic approach to data collection with notes on context and assumptions enables the process to be transparent, reviewed, revised and improved. For example, price data may be affected by market distortions, as a result of government subsidies, sales taxes or minimum price policies. Sensitivity analysis of changes in parameters is a useful way to understand how much an estimate affects the final results of an opportunity cost and tradeoff analysis (discussed in Chapter 7).

56. The following section is divided into two parts to address particular data aspects of (1) agriculture/ranching, and (2) forest land uses.

Agriculture and ranching

57. Farmers can usually recall yields prices paid and received for the most recent season. In the absence of farm gate prices, other price data should be adjusted based on value-added marketing activities. For example, wholesale market prices of rice include the added

value of milling and farm-to-market transportation costs. If market prices are used, the cost of milling and transport should be subtracted in order to arrive at farm gate prices.

58. Agricultural census and government statistical information at provincial or department level can confirm yield estimates. With estimates of total crop area, such sub-national production figures can be converted to a per hectare basis. Even if farm-level data is used within the analysis, government census statistical information is helpful to check data accuracy.

59. On smallholder farms, many separate activities often occur in within a small patch of land. Slash-and-burn systems typically include a wide range of agricultural crops including rice, maize, beans, cassava, plantain, etc. To represent slash-and-burn agriculture in Peru for example, a rice-plantain-fallow cycle, which is common to the region, is used. The cycle can be adjusted according to age of forest frontier by changing the length of the fallow period. Similarly, pasture productivity is adjustable according to animal units (head of cattle per ha).

60. Since remote detection of individual crops is notoriously difficult, a subset of the major activities can be selected to represent a mixed land use, thereby reducing the need for detailed data collection. Similarly the productivity of pastures within a landscape is not possible to assess without on-site information.

61. Smallholder practitioners of slash-and-burn farming rarely have precise measures of their field size. This is particularly common in regions where land markets and land titling are not developed. In such cases, accurate estimates of field size may be obtained by walking the field perimeter with a handheld GPS.

62. Markets may not exist or function well in remote regions. For example, services such as wage labor could simply be unavailable for purchase. Since minimum wage rates are often poor approximations of actual rural wage rates, analysts are best advised to consult local experts about realistic wage rates. Even in remote areas, the hiring of casual workers is common. The daily wage is often quite standardized and known within a given locality. Since minimum wage rates are often poor approximations of actual rural wage rates, analysts are best advised to consult local experts about realistic wage rates.

63. Alternatively, hired laborers are commonly paid on a piece-rate rather than a monthly, daily or hourly wage basis. This complicates wage rate sensitivity analysis as this labor cost is a lump sum payment and therefore requires a data transformation. Perhaps the simplest way is to divide the lump sum payment by the wage rate to estimate the equivalent quantity of wage labor that could have been employed. Sharecropping is another labor institution common to smallholder agriculture in developing countries that requires a similar treatment.

Forests

Timber

64. Since the logging industry is highly competitive and under the scrutiny of tax officials, acquiring financial information can be particularly difficult. In addition, most timber extraction (around 90%) in the Amazon is estimated to be illegal (Stone, 1998). Operations are often led by self-made managers who have little business management training, deficient bookkeeping practices, and limited financial control of forest operations (Arima and Veríssimo, 2002, Pearce, et al. 2003). Nevertheless, personal interviews, mail surveys and informal discussions with industry experts may provide needed information.

Other forest products

65. Data collection methods for non-timber forest products (NTFPs) appear in numerous studies. Sheil and Wunder (2002) provide a useful critique of methods applied. For charcoal products, few studies exist; examples include: Hofstad (1997), Coomes and Burt (2001) and Labarta, et al. (2008).

Land use budgets

66. Information from enterprise budgets is essential to estimating the profitability of land uses and land use trajectories. For land uses with more than one product, land use budgets require managing revenue and cost information of separate enterprise budgets. Thus the representation of profit is:

$$\Pi = \underbrace{\left(\sum_{h=1}^{H} p_h q_h + \sum_{i=1}^{I} p_i q_i \right)}_{\text{Revenues}} - \underbrace{\left(\sum_{j=1}^{J} c_j y_j + \sum_{k=1}^{K} c_k y_k \right)}_{\text{Costs}}$$

67. The above equation makes explicit not only the prices and multiple market goods and services of a land use, (p_h and q_h) but also the non-market prices (p_i) of non-market goods and services (q_i). Within a specific land use, the inputs may include both marketed inputs (y_j) and non-marketed inputs (y_k), which have distinct valuation challenges (of c_k). The use of shadow prices for non-marketed goods is common.

68. The enterprise budget example for rice above is a single year. Land uses, however, typically require a multi-year analysis, since annual profit levels can be very different (negative, zero or positive) depending on phase: establishment, fallow or production. Therefore, the above equation becomes:

$$\Pi_{land\ use} = \sum_{t=1}^{T} \Pi_t$$

69. The file **SpreadsheetExercisesREDDplusOppCosts.xlsm** (available on the manual website) contains examples of land use budgets with different phases and products. Such detailed budgets help analysts keep track of individual activities and enterprises as they change over time. Notes on how the costs and earnings change help analysts understand the assumptions employed and site context.

70. For some land uses, complementary activities should be noted, if not included in estimates. For example, fodder production for feeding animals that provide transport or other farm activities, such as plowing, should be attributed a proportional use basis. Details of such assumptions are discussed at the end of the chapter.

Agriculture

71. Land use budgets can be developed to represent both land use change cycles and transitions (see Chapter 3 for definitions). Distinct versions of land use budgets can different locations and context, such as within a forest frontier. For example in Peru, swidden agricultural production typically has a three year production phase, but different fallow periods according to age of settlement. Farmers in established settlements with higher population pressure commonly practice shorter "bush" fallows of 2-6 years. In contrast, pioneer farmers typically leave their lands fallow for longer periods, 6-15 years. Since both input (e.g., labor) and output (e.g., harvest) levels are different between such systems, separate budgets are justified.

72. Land use budgets of perennial systems, such as tree crops (cocoa, oil palm) and cattle, include costs of establishment and production. These multi-year budgets could typically have high investment costs and require numerous years before revenues exceed costs.

73. The workbook of land uses contains example spreadsheets of cocoa, oil palm, cattle, rice-plantain systems. Cells, highlighted in yellow, represent parameters that can be adjusted to better represent local conditions. Different contexts and land management practices should be examined within scenario analyses of land use trajectories. Adjustments of parameters such as yields could include harvest increases that represent new seed and fertilizers or harvest decreases resulting from land degradation. In addition, ash flow constraints (especially with cattle and perennial systems) may require land uses to be phased in as funds become available.

Forests

Timber

74. Forest harvest operations are typically diverse, ranging from small-scale informal loggers to vertically-integrated harvest, transport and processing firms. Therefore, different budgets for timber harvests are needed for each major variation that is observed in a country.

75. Timber cost analyses are typically divided according process stage: timber harvest, transportation and milling. Harvesting comprises a set of activities undertaken to fell and extract trees to a landing or a roadside where they are processed into logs and consolidated. Logs are then transported over unpaved and paved roads to a processing facility or other final destination. Milling refers to log sawing activities into a variety of different shapes and dimensions. The spreadsheet named **Timber** is an example of an enterprise budget for logging company. The level of detail can be expanded per process stage, by including estimates for the costs of labor and equipment, for example. For a comprehensive explanation of costing procedures, see Holmes, et al. (1999).

76. Forests can generate substantial profits or losses. Whether the profits are positive or negative, depend upon how forests are used and if products are sold. To understand the variety of forest uses and products, two aspects of forests need to be considered: ***forest quality*** and ***forest use***.

77. ***Forest quality*** refers to the status of the forest with respect to previous use by people. Many relatively dense forests have already undergone a series of changes, including extractions of high-value tree species and selective logging. Hence, forest quality is also a measure of forest degradation.[56]

78. While degraded forests can still be forests, according to definition, the carbon content and future profits can be substantially different from natural forests. A previously-harvested forest, for example, will not generate the same profits as a pristine forest. In order to enable a rigorous accounting of forests, distinct forest quality categories need to be developed. For the purposes of this training manual, general categories are employed, consisting of: pristine or natural, selectively cut (highest value species extracted), and partially cut (high-mid value species harvested). In order to obtain more precise estimates of forest profitability, sub-categories with greater levels of distinction and detail may be required per country context and REDD+ program criteria.

79. Past activities will affect future potential uses of the forest. Thus, in contrast to forest quality, ***forest use*** refers to upcoming activities within a forest. For example, pristine or

[56] Although specific definitions of forest quality (e.g., carbon content and canopy cover) will likely differ according to national contexts and perhaps differ within a country. Forest categories and their geographic identification can be linked with land uses discussion.

natural forests have had few human activities but a wide range of potential uses. Respective select- and partially- cut forests have increasing levels of previous use, yet fewer potential uses. Fewer potential uses implies lower profitability. Per forest quality category, Table 6.4 summarizes both previous and potential forest uses.

Table 6.4. Past and potential forest uses per status of forest quality

Forest quality status	Past uses	Potential future uses
Pristine or natural	NTFPs Tourism	NTFPs Tourism Highest-value trees extracted High-mid value tree harvests Forest conversion (timber, charcoal) Other land uses (agriculture, ranching)
Selectively cut	Highest-value trees extracted NTFPs Tourism	NTFPs Tourism High-mid value tree harvests Forest conversion (timber, charcoal, pulpwood) Other land uses (agriculture, ranching)
Partially cut	Highest-value trees extracted High-mid value trees harvested NTFPs*	NTFPs Forest conversion (timber, charcoal, pulpwood) Other land uses (agriculture, ranching)

** can also include areas of slash-and-burn agriculture, depending on land use definitions and resolution of analysis.*
Source: Authors.

80. Forest quality also determines possible timber harvests. Select cut- or partial- timber harvests, for example, decrease carbon content and potential near-term future profits, albeit less than clear cutting. While selective forest harvest practices may not cause a land parcel to lose its distinction as a forest, their effects on carbon and potential future profitability need to be assessed.[57] For example, after thinning (e.g., selective harvest) remaining trees grow faster.

81. Often used to describe forest use are the words ***sustainable*** and ***unsustainable*.** For the purposes of estimating REDD+ opportunity costs, however, the distinction is not sufficiently precise. Sustainable use activities, such as from non-timber forest products (NTFPs) or tourism, do not affect the carbon content and forest quality. Yet, other "sustainable" practices, such as sustainable forest management, are likely to reduce carbon content and forest quality - although less than conventional logging practices.

[57] The opportunity costs of conserving selectively logged forests can be substantially lower and thus more affordable from a REDD+ point of view. "Log and protect" might thus become a way to avoid substantial emissions.

82. Profits from forests can also be generated in other ways. A lesser-known forest use and income source is the production and sale of charcoal, which is used as a cooking fuel. As an enterprise activity of a smallholder farmer, for example, charcoal production in the Peruvian Amazon can generate substantial earnings. A whole-farm profitability analysis estimates that charcoal-producing farmers generate 17% higher net income from their farm than merely slashing and burning the forest (Labarta et al. 2007).

83. When trees are not sold, forest conversion costs are not offset by income, thereby causing sometime substantial profit losses in the initial year. Especially in remote areas, many farmers, prefer to burn trees on-site since expensive transportation often erases potential earnings. In such cases, the cost of clearing land typically exceeds the initial years of revenue generated from agriculture or pasture activities (Kotto-Same, et al., 2001; Merry, et al. 2001; White, et al. 2005).[58]

84. Experiences from Brazil, the largest timber producing country in the tropics, and Peru are used to illustrate costs and revenues from the timber industry. Cost studies examined the entire sequence of activities related to forest operations, including cutting, skidding, landing activities, and transportation. Also included were costs for construction and maintenance of infrastructure (landings, and primary and secondary roads) and the costs for capital items (e.g., capital costs, depreciation, maintenance), labor, material, administration, and stumpage fees.[59] Most studies took into account transportation costs from the forest site to the sawmill along public roads, whereas costs representing risks and administration salaries were largely ignored. Some studies used standard costs for labor and machinery, while others relied on data specific to the different activities.

85. Studies of logging operations provide numerous cost and revenue estimates. Profit estimates show significant variation – ranging from US$24/ha to US$1435/ha (Olsen & Bishop, 2009). In reviews of forest operation studies, Pokorny and Steinbrenner (2005) and Bauch, et al. (2007) found that differences in cost estimates arose from contextual conditions of:

- particular forests (e.g., species composition, forest structure, topography),
- commercial enterprises (e.g., staff, machinery, work processes, organization, wage rates),
- harvesting strategy
    - conventional logging (CL) and reduced impact logging (RIL) practices. (See Box 6.5) for a description of the logging techniques and cost
    - distance from the forest to the processing location
- cost calculation methods (overall costs versus specific sub-activity), and

[58] Although trees can used for many local uses, their estimated value is relatively small and therefore not included in an analysis of profits.

[59] Stumpage fees are the cost of purchasing the rights to log a parcel of land. Payment is typically made on a m^3 basis. Such fees are a component of opportunity cost of logging - the value of the trees to the landowner.

- approaches used for data collection.

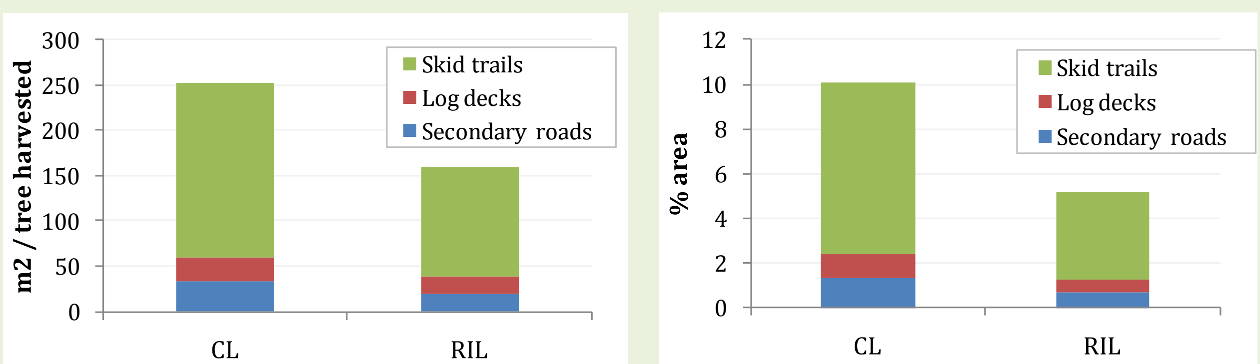
86. The conversion rate from logs to sawn timber is a useful factor to contrast efficiency (and profitability) of timber harvest operations. Stone (1990) considers a conversion rate of 47% while Stone (1995) considered a conversion rate of 34%.[60]

Box 6.4. Reduced impact logging

Reduced impact logging (RIL) can be more profitable than conventional logging (CL) practices. Despite requiring investments, RIL can accrue benefits in the both short and longer term. At an initial harvest, forest worker training generates efficiency gains to skidding, recovery of potential marketable timber and log deck[61] productivity. Longer term economic and ecological benefits of RIL include less damage to residual trees and disturbed soils (Holmes, et al. 1999).

In a case study analysis, wood wasted in the CL practices represented about 24% of the harvest volume, but only 7.6% with RIL techniques. Less wood wasted and increased wood volume can reduce costs by 12% per cubic meter versus a typical CL operation (Holmes, et al. 1999).

The FAO model code of forest harvesting provides the basis for RIL system design, including many or all of the following activities: pre-harvest inventory and mapping of trees, pre-harvest planning of roads and skidtrails, pre-harvest vine cutting (where needed), directional felling, low stump cuts, efficient use of felled trunks, optimum width of roads and skid trails, winching of logs to planned skid trails, optimal size of landings, minimal ground disturbance and slash management (Dykstra and Heinrich 1996).



Ground area disturbed by CL and RIL (m² per tree harvested and % area)

Source: Holmes, et al. 1999.

Although RIL is not a fixed prescription, the techniques and guidelines attempt to adapt best harvesting practices to existing biophysical and economic conditions. Pre-harvest,

[60] The revised rate, reflecting less efficiency is one of the main factors behind Stone's conclusion that timber profits are decreasing (Bauch, 2010, personal communication).
[61] Location to where logs are skidded stacked for subsequent loading onto trucks.

harvest planning and infrastructure costs of CL operations were \$0.71 per m^3 and \$1.93 per m^3 for RIL. In some cases, RIL can be more expensive or of similar cost to CL depending on sophistication of the CL (e.g., harvest planning) and particular practices of RIL (Winkler, 1997; van der Hout, 1999). Effects of RIL on carbon density stock and regeneration capacity of the remaining have not yet been estimated. Nevertheless, the REDD+ opportunity costs of different forest management strategies can be examined through sensitivity and scenario analyses.

87. Timber waste is a concept related to conversion rate. Timber waste arises from felled logs not being skidded and young trees of commercial value being needlessly destroyed. In mills, waste is produced when logs degrade during storage and inaccurately sawn lumber (i.e. excessive thickness) (Gerwing, et al. 1996). According to Pokorny and Steinbrenner (2005), the multiple components of timber waste from field to mill, resulted in greater differences in the costs than single estimates of field productivity.

88. Profit estimates of logging operations can also differ because of assumptions regarding timber quality and prices received. Since many forests within a country may have already been harvested, timber profits could substantially differ per region. An assessment of current forest quality and potential forest uses establishes a starting point of analysis for estimating future profits.

89. The profits generated from high value forests can be substantial. A case of mahogany harvests in Brazil is an example of high profits with potentially low carbon impact (Box 6.6).

Box 6.5. High-value mahogany - but with what carbon effects?

High value species extracted from forests generate large profits with relatively little effect on forest carbon. In Brazil, for example, mahogany trees are usually widely scattered in patches. On average, 5 m^3 of mahogany logs are extracted per hectare and generate \$81 per hectare in profit, despite their high (\$150 per m^3) harvesting costs (Verissimo, et al., 1995).

While this type of forest impact may be small, associated harvest practices can have greater effects on forest quality. Most logging operations use conventional harvesting techniques, sometimes termed high impact, that severely damage and degrade forests. Skidder road construction and damage to other trees during felling can affect both carbon and forest canopy. Yet, such effects are not typically included in deforestation maps (Nepstad, et al., 1999). In addition, since only a portion of the tree is being harvested, a substantial amount of the biomass is not of commercial quality. The unused portion of the tree should to be considered within carbon accounts of forests.

To assess selective logging, budgets should be estimated for the forest land with logging (and any subsequent land uses in the trajectory) and for the same forest land without such logging. The profitabilities can be compared with differences in C stocks under the two land uses in order to estimate the REDD+ opportunity costs.

Other forest products

90. Estimates of profits generated from NTFPs also vary widely according to study methods, products gathered and economic context. In a meta- analysis of NTFP studies, Belcher, et al. (2005) estimated the value of three types of NTFP production (US$/ha): wild ($1.8), managed ($3.8), and cultivated ($25.6). Costs of collection, especially labor inputs, are difficult to measure comprehensively and are not reported extensively in the literature. Although likely to be minor, corresponding levels of carbon in forest and the effect of gathering on carbon stocks were not examined.

Reforestation

91. Since the 2010 UNFCCC meetings in Cancun, the enhancement of forest C stocks has been included with REDD (thereby becoming REDD+). This implies, for example, REDD+ eligibility would include changes from: (1) a particular non-forest land use returning to forest, or (2) a degraded low-carbon forest to a forest with higher carbon content.

Profitabilities of land use trajectories

92. With land use budgets, we now have an analytical framework and sufficient information to analyze the profitability of land uses over many years. Where needed, the enterprise budgets have been combined into multiple year budgets representing a land use. Yet, since land uses can change over time and credits represent carbon contained in land uses for multiple years (specifics not decided yet within REDD+ policy), a profit analysis of land use trajectories is called for when estimating REDD+ opportunity costs. Although the length of the time horizon for analysis can be an arbitrary decision, it should be guided by REDD+ policy. Common analysis horizons range from 20 - 50 years, and perhaps more.[62] For the purposes of this manual, a 30-year horizon is used.

93. Sample results of a profit analysis from Peru are summarized in Figure 6.6 and associated Table 6.5. For each land use change in the Peru case, profits in the first year are negative. This is due to the high investment costs of preparing the land for subsequent agricultural or tree production.[63]

94. Profits also differ each year for most of the land uses. While not producing greater profits, agriculture and pasture systems generate profits earlier than tree-based systems.

[62] The longest horizon of CDM project activities, other than Afforestation/Reforestation (A/R), is 21 years. For A/R activities, the time horizon is 20 to 60 years (UNFCCC, 2010).

[63] When timber can be sold, for example, first year profits are typically high. Likewise, first year profits can be positive when clearing costs are low (e.g., using burning with little slashing) and first crops are obtained quickly (annual crops).

In the Peru example, the agricultural systems are based on either short- and long- fallow systems, which produce positive profits in years two and three. During the fallow periods of 4 and 8 years, respectively, no costs or earnings result in zero profit.[64]

95. With ranching land uses, although the initial costs of seeding pastures can be low, other establishment costs such as cattle purchases and fencing are high. The costs of establishing an improved pasture are greater than a native pasture, generating double the profits after year 1.

96. The profits of perennial land uses depend on investments required to establish the system, intercropping activities and the number of years until production from the trees. The tree-based systems generate negative profits (losses) for one or two years, given that weeding and other investments are typically required before production.

97. These sample results are highly sensitive to yield, price and input assumptions. Parameters, within the enterprise or land use budgets, can be adjusted to represent different socio-economic and biophysical contexts. The interconnected information enables rapid review of how parameter estimates affect profitability of a land use. More on the topic of sensitivity analysis, in Chapter 9.

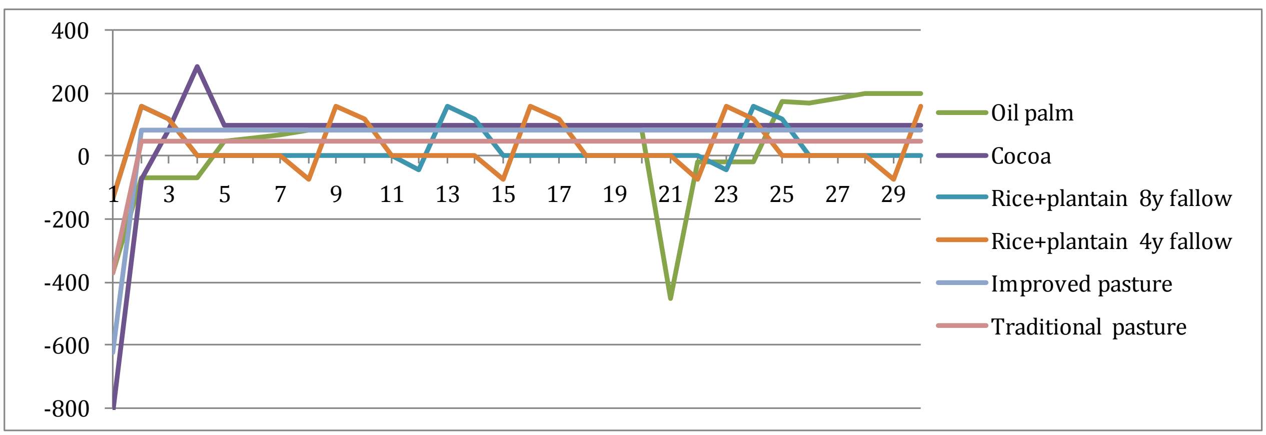


Figure 6.6. Sample multi-year profit analysis (undiscounted values, $/ha)

[64] The rental rate of land is considered to be zero. Discussion on this assumption below.

Table 6.5. A multi-year profit analysis results, Peru (undiscounted; years 1-15, 30)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	30
Oil palm	-264	-70	-70	-70	46	57	69	81	81	81	81	81	81	81	81	200
Cocoa	(815)	(75)	84	284	97	97	97	97	97	97	97	97	97	97	97	97
Rice+plantain 8y fallow	-133	158	115	0	0	0	0	0	0	0	0	-45	158	115	0	0
Rice+plantain 4y fallow	-133	158	115	0	0	0	0	-73	158	115	0	0	0	0	-73	158
Improved pasture	-633	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74
Traditional pasture	-384	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38
Charcoal	378															
Charcoal+oil palm	114	-70	-70	-70	46	57	69	81	81	81	81	81	81	81	81	200
Charcoal+rice+plantain 8y fallow	245	158	115	0	0	0	0	0	0	0	0	-45	158	115	0	0
Timber	450															
Timber+improved pasture	-183	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38
NTFP collection	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Net present value

98. The above multi-year profit analyses illustrate how profit levels change annually during a time horizon. Despite all the results, it is not easy to determine the most attractive land use with respect to overall profitability. A land use may generate the highest profits, but occur at the end of a time horizon.

99. Net present value (NPV), or sometimes called present value, is a calculation commonly used to estimate the profitability of a land use over many years. NPV takes into account the time-value of money. Since waiting for profits is less desirable than obtaining profits now, the "value" of future profits is discounted by a specific percentage rate, often ranging from 2- 20%.

100. With multi-year analysis, NPV is a discounted stream of profits (revenues minus costs of capital, land and labor inputs).

$$NPV = \sum_{1=t}^{T} \frac{\Pi_t}{(1+r)^t}$$

Where t = year, T = length of time horizon, Π = annual profits of the LU ($/ha), r = discount rate. The major assumptions introduced at the stage of NPV calculation are the discount rate (r) and the time horizon (T).

Which discount rate should be used?

101. For discount rates, NPV analyses typically use loan interest rates, which are set by a national bank or the government. Such rates can range from 10-30%. Although agricultural loans are rarely available, especially in remote forest margins regions, bank interest rates do serve as a good indicator of the time value of money.[65] The interest rate reflects the opportunity cost of obtaining profits - not now - but in the future.

102. High discount rates can dramatically reduce the viability and attractiveness of long-term investments. These include enterprises such as forestry, agroforestry, and cattle systems where initial years require up-front investments and payoffs occur 5-20 years later. Costs are scarcely discounted, whereas the value of future earnings can be significantly lower.

103. Another interpretation of the discounting effect from high rates is that future values do not matter. Since future profits are heavily discounted, they are not important. This can also be translated into saying that the benefits to future generations do not matter. The context of high discount rates creates incentives to generate profits and benefits in the short term, since waiting for the long term is nearly worthless. For example, the use of high

[65] Furthermore, smallholder farmers rarely have title to their land or tangible assets to use for collateral to be able to borrow funds.

discount rates challenges the view of conservationists who consider current and future values of biodiversity to be high. Therefore, in order to value ecosystem services, a lower (social) discount rates could be more justifiable than higher discount rates used in a risky (private) business environment.

104. In sum, it is important to select a discount rate the reflects the transaction within the market and policy context. REDD+ programs are not based on the context of smallholders conservationists or businesses. The national accounting system of a country is likely intermediate and appropriate financial context of a REDD+ program. Therefore, within this training manual a 5% discount rate is employed. To see how NPV can be calculated in computer spreadsheets, examine sheet **30-year analysis** in the example workbook. The combination of enterprises that comprise each land use has been defined in 0. Now, in sheet NPV, a function within is used to calculate the NPV of the profit stream for each of the enterprises in a given LUT. The sensitivity of results to this assumption is examined in detail below and within 0.

Results of profitability analysis

105. Results of a sample profitability analysis are in Table 6.6. NPV estimates for the 30 year timeframe and 5% discount rate range from $15 per ha for NTFP collection to $1047 for a timber and improved pasture land use trajectory. The next lowest performing trajectory was traditional pasture. Low productivity and initial investment costs decrease the NPV estimates. In contrast, the inclusion of profits from either timber or charcoal sales significantly increases NPV estimates. Charcoal profits more than double the NPV of a rice-plantain swidden system. Similarly, the NPV of an improved pasture system nearly doubles with the inclusion of profits from timber.[66]

106. All these results are highly dependent upon yields, prices and cost of inputs. Adjustment to parameters of particular land uses can be made within the corresponding spreadsheets.

107. Figure 6.7 show the discounted profit horizon of 30-year trajectory. In comparison to the undiscounted horizon, the discounted values during the latter years are closer to zero. This holds true for both positive and negative (investments) profits that occur in the distant future.

[66] By law in Brazil, the minimum harvest cycle for tropical forests is 25 years. Although there no forest has been managed (and survived) for that long in order to be able to assess feasibility of another harvest in year 25, NPV could be higher based on a 2nd harvest; see van Gardingen, et al., (2006) for forest regrowth models.

Table 6.6. Profitabilities of land use trajectories (5% discount rate, 30 year analysis)

Oil palm	**245**
Cocoa	604
Rice+plantain 8y fallow	**302**
Rice+plantain 4y fallow	**409**
Improved pasture	618
Traditional pasture	**336**
w/Charcoal	360
Charcoal+oil palm	605
Charcoal+rice+plantain 8y	662
w/Timber	429
Timber+improved pasture	1047
NTFP collection	15

Source: Authors.

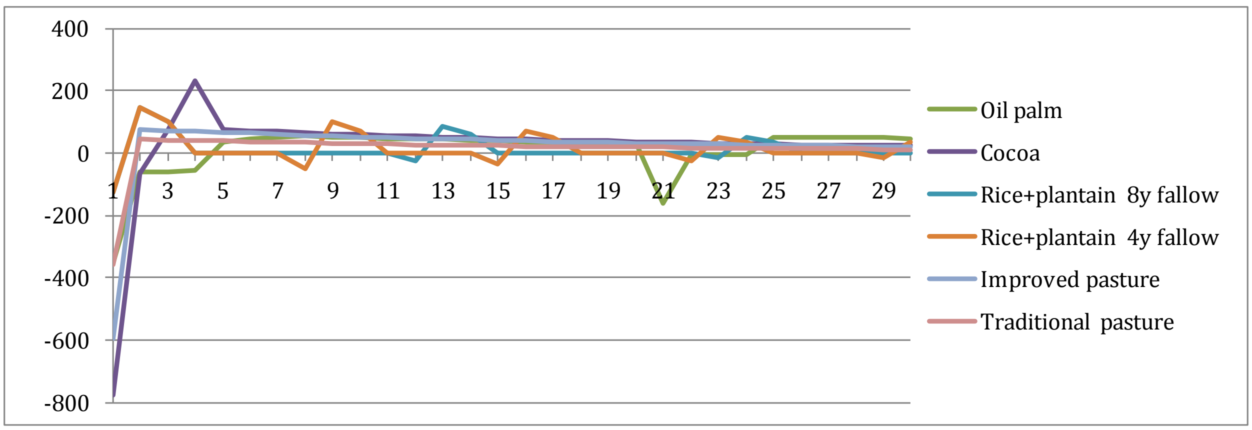


Figure 6.7. Sample multi-year profit analysis (5% discounted values, $/ha)

Source: Authors.

Backend issues – more methods and assumptions

108. Since the results of profitability analyses always depend on a series of assumptions (e.g., data sources or discount rate), results can and should be questioned. It is therefore crucial to review profit estimates and the step taken to generate them. In this section, we revisit important elements of profitability analysis and discuss the implications of assumptions.

How to handle shared and long-lasting inputs

109. If farm inputs are used for more than one enterprise, the cost of input should be shared and attributed to the other enterprises. If the cost were to appear within the budget

of one enterprise, the profit would be incorrectly reduced while other activities become more profitable.

110. To account for shared inputs, it is recommended to use rental rates per hectare or day to approximate the cost of tools and machinery (e.g., chain saws, machetes, tractors, etc.). For long-lasting inputs, prices and average lifetime values can be estimated to impute annual use cost per hectare. Analysis can also depreciate the value of the input according to a depreciation schedule (for details, see Gittinger, 1982).

How to estimate budgets for hypothetical land uses

111. Countries may want to estimate hypothetical land use practices within a profitability analysis. Some practices are not currently observed but may have higher carbon benefits than current practices (e.g., RIL). Also, other potentially new land uses might come about (e.g., biofuel production).

112. When estimating hypothetical cases, extra caution should be taken. Often prospective budgets make unrealistic assumptions in order to obtain funds for research and implementation. Careful review of the literature about projected yields and associated costs savings are recommended. In addition, both the socio-economic and bio-physical conditions of case studies should be comparable to the proposed locations.

How to account for inflation

113. Estimates should be calculated in real terms. In other words, inflation is accounted for in the analyses, whereby the NPV analyses combines the discount rate with the inflation rate (Real Interest Rate = Nominal Interest Rate – Inflation). Analyses using real rates are important as they show the actual increase in value, and how much of a return was just the effect of inflation.

Time horizon of a net present value analysis

114. For NPV estimates to remain comparable across enterprises and land uses, the same time horizon must be used in all analyses. This manual uses a 30-year timeframe. As we are interested in the opportunity cost of entering a REDD+ contract, the choice of the time horizon may have important implications for buyers and sellers of emissions credits. If the time horizon for NPV calculation exceeds the respective REDD+ contract duration, opportunity costs may be overestimated and vice versa.

115. The use of a higher discount rate and longer time horizon can help to improve the methodological consistency when estimating the land use profits. Since harvest cycles of different land uses are likely to have differing period lengths, discrepancies can result within a time horizon. For example, some land uses may end in the end or middle of a productive phase while other may be in a fallow stage. (Note that in Figure 4.6, the agriculture-fallow cycles are not complete within the time horizon.) Fortunately, the discount rate can cause the contribution of later year profits to be less significant.

116. If a short time horizon is used, then substantial residual values may arise for many land uses. Using a long time horizon can be easier (long enough that, under whatever discount rate is chosen, any benefits or losses beyond the time horizon no longer matter) than to use a short horizon and have to compute and enter residual values.

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