# DOWNLOAD PDF MEASURING AND MANAGING ENVIRONMENTAL COSTS

## Chapter 1 : Cost Of Quality (COQ) - ASQ



The current lack of development in related internal management-reporting, decision making, and cost-accounting systems is argued to be the major inhibitor to further improvement. The Industrial Green Game: Implications for Environmental Design and Management. The National Academies Press. Over the past 3 or 4 years, it has become normal for the largest U. Some of these companies provide an extensive review. Within Europe, the amount of disclosure of environmental information appears higher in Germany than in any other country Roberts,  Much of the information currently provided in the United Kingdom remains nonspecific. Emphasis is on statements of policy with relatively little quantification of technical or financial factors; quantified achievements against targets are provided by a few companies such as ICI, British Telecom BT , and IBM-UK. Even when quantification is provided, only a few financial implications are mentioned. The report also refers to some of the financial savings achieved through reductions in waste, energy, and water usage. British Petroleum BP devoted nearly a full page of the financial review section of its annual report and accounts to environmental investment. Potential contingent liabilities also were discussed Accountancy,  Information on environmental costs in financial statements or notes thereto is more common in the United States where there are Securities and Exchange Commission SEC and Financial Accounting Standards Board requirements relating to disclosure of such information Macve and Carey,  Over 25 percent of the U. There is increasing debate worldwide as to what extent more explicit guidance should be given by regulators and accounting bodies to companies on their reporting of and accounting for environmental costs. Most of the concern regarding financial accounting has focused on issues such as the reporting contingent liabilities for environmental restitution costs and penalties and of impairment to land and other asset values. Issues that need to be dealt with under ordinary accounting and reporting requirements differ in their environmental aspects, mainly because their potential financial impacts may prove much larger than those that companies have already faced. As such, they are of enormous potential concern to investors and lenders and hence to regulators such as the SEC. The major inhibitor, however, is the inadequacies of internal environmental-management systems. Few companies have systems "that allow them to produce this kind of data and therefore many have a significant hurdle to jump before they can produce an environmental report for public consumption" KPMG, , p. Top-down mission statements are inadequate without a wholesale change in management culture from top to bottom and in the education, training, and incentives provided to middle managers and other employees. To effect these changes, several steps may be taken Macve and Carey,  Management should establish clear lines of responsibility on environmental matters and give a board member overall responsibility for such issues. The company should set out its environmental policy, prioritize objectives, and develop information systems for monitoring performance. This is needed for external regulation and reporting as well as for internal decision making and control. This is necessary to provide clear signals and incentives for action at all levels throughout the organization. There should be an internal environmental auditing program to ensure that environmental policies are being implemented properly. Companies that may suffer environmental incidents, such as oil spills, should establish procedures for managing such events. The evidence that companies are achieving necessary internal changes is less than that for external reporting. It is not yet clear whether this is because the changes have not yet taken place or because researchers have not yet investigated them adequately. Accounting systems also may fail to evaluate the potential benefits of environmental decisions. Thus, an exercise by the U. Environmental Protection Agency EPA and Du Pont, and a similar exercise in the United Kingdom on individual sites in the Aire and Calder Valley, showed that there are "many pollution prevention projects with paybacks of less than a year which are not being implemented," either because of competition for management attention or the difficulties

of identifying the relevant causal Page Share Cite Suggested Citation: A change in approach is needed if companies are to move from "end-of-pipe" clean-up solutions to preventative design. To provide a disciplined framework for evaluating all relevant costs, EPA has developed the total cost assessment TCA method, and experiments have been undertaken to investigate the effect on decision making about pollution-prevention projects in the pulp and paper industry Tellus Institute, In the two projects studied, the new recognition that costs result from not adopting the prevention measures in particular, future liability costs and foregone energy savings for freshwater and wastewater pumping and treatment and for freshwater heating improved the financial acceptability of the prevention investments on all normal decision criteria net present value, internal rate of return, and payback. Tier O, direct costs only; Tier 1, Tier 0 plus indirect costs overheads ; Tier 2, Tiers 0 and 1 plus legal liability costs; and Tier 3, Tiers 0 through 2 plus intangible costs and benefits. Conventional accounting systems and evaluation procedures measure the indirect costs at Tier 1 but suffer either from not tracing these costs to processes and products or from allocating them arbitrarily, distorting their relevance Todd, Tiers 2 and 3 may not be recognized at all. A paradox exists here. This leads to concern that market-based incentives such as taxes and tradable pollution licenses may not be effective if companies are unable to recognize the relevant costs and benefits. The approach also raises the organizational issues of why current accounting systems are inadequate. Tellus Institute points to the additional complexities of the evaluation procedures it recommends and the additional time needed to undertake them. A cultural change is needed if managers are to give sufficient priority and attention to such evaluation schemes. Without a shift in thinking, approaches like TCA will not be able to compete with other potential investments and activities or be considered as viable options in the capital budgeting process. If managers do not get over that first hurdle, there will be no opportunity for the merits of the TCA analytic procedures to be demonstrated. TCA methodology has controversial aspects. For example, the time horizons may need to be extended to capture the most significant costs and benefits especially relating to future liability. There is also the broader issue of whether the discount rates normally used reflecting capital market requirements properly reflect "social time preference" as between current and future generations Milne, ; Tellus Institute, TCA itself has been criticized as incomplete: However, a management thinking strategically about environmental issues and likely changes in pressures from external stakeholders should also be considering possible future costs and benefits arising from, for example, new regulatory requirements or changes in consumer perceptions. The emphasis must be on the total life cycle costs and benefits to the company 5 from current, future, and potential perspectives. Here, there is a potential link to the need for accounting to develop ways to measure impacts on the environment. Companies have begun to move up the TCA tiers. Bennett and James have interviewed companies, including Rhone-Poulenc, Baxter Healthcare, and 3M, that have identified ways to save costs by expanding their identification of relevant environmental costs. Organizational Changes Attempts have been made to identify the organizational difficulties that inhibit such developments. Information may need to be collated from various functions sales and marketing, manufacturing, purchase, supply, research and development, finance, personnel, etc. Houldin, , and responsibility may need to be relocated. A move to a TCA-like approach, therefore, may be resisted by managers who have a vested interest in the status quo Todd, Therefore, positive steps, which may require external regulatory stimulus, are needed to overcome organizational inertia. It does not appear likely that this initiative will come from accountants themselves. A recent study of the attitudes of accountants, based on a questionnaire survey of the finance directors of the 1, top U. However, there are also, surprisingly, many accountants who have no plans to address or even claim never to have heard of any of these issues; two-thirds or more expressed negative views about issues such as packaging, legal compliance, environmental budgets, water pollution, recycling, contingent liabilities, remediation costs, air pollution, land pollution, sustainability and life Page Share Cite Suggested Citation: By contrast, the attitudes expressed by accountants indicate enthusiasm for innovation and development of new systems, recognition of increasing regulatory demands especially from the U. The researchers speculate that there may be aspects of the nature of professional accountancy training which emphasizes financial measures,

precision, prudence, and resistance to changeâ€”caricatured as the bean-counters who say "no" that inhibit accountants from initiating or even responding readily to change. The official pronouncements from professional accountancy bodies that encourage greater environmental activity e. We found it extremely difficult to see how we could put these things [environmental matters] into the accounting records â€¦ accounting approaches encourage short-term attitudesâ€”community investment, like environmental investment, requires a long-term attitude. Incentives The critical problem of performance assessment has bedeviled many environmental initiatives Gray et al. Ex ante control â€¦ does not guarantee success. That is, the ex post audit and evaluation must take explicit cognizance of the environmental criteria. This is especially difficult in highly decentralized organizations. Managers soon learned, however, that if they failed to meet financial targetsâ€”as opposed to environmental, BATNEEC considerationsâ€”they were penalized. Page Share Cite Suggested Citation: Thus, employees receiving a score of 80 out of on meeting the environmental objectives, receive 80 percent of their bonus. A score of less than 70 is considered unacceptable: It is with such approaches that corporations can effectively change their cultures and provide for a significant change in the environmental sensitivity of all employees at all levels. Such developments in incentives do not seem to be widespread at present. However, individuals are essential elements of the sustainable development process, both as decision-makers in the company and as decision-makers in the government. The implication is that "sustainability can no longer be decoupled from individual responsibility" Whelan, , p. If the accounting incentive-reward structure for individual organizational members is not brought into line with environmental objectives, it will be difficult for the organization as a whole to respond effectively to the environmental challenge. At Monsanto, an internal tax is imposed on all internally generated waste, thereby doubly penalizingâ€”and doubly motivatingâ€”management responsible for waste production. Such initiatives are pointers to the kinds of developments that may be experimented with Gray et al. Small Firms A particular issue, identified in a recent white paper on sustainable development U. Government, , is how small firms, including agricultural enterprises, are to be given incentive to adopt more environmentally responsible behaviors. Their access to information about environmental issues and opportunities may be much more restricted than that of larger firms. For such firms, cost savings from environmental investment may also differ from those for larger firms. However, Epstein , p. This section covers three major issues that remain problematic both in theory and in practice: Costs of or to the Environment? Most of the initiatives discussed above deal with environmental impacts on companies such as the potential liabilities or asset impairments that may need to be reported in external financial statements and the potential cost savings and other benefits that may need to be recognized if companies are to take appropriate action to reduce waste, prevent pollution, etc. This approach avoids conflicts between these often contradictory outcomes because the externalities that it imposes do not presently have to be internalizedâ€”through regulatory or fiscal mechanismsâ€”as its own costs. Thus, reporting of expenditures on environmental cleanup may not signify an environmentally "friendly" company but an "unfriendly" company that is doing something to mitigate the environmental damage it is causing. See, for example, Milne,  Various bodies such as the United Nations and International Institute for Sustainable Development have called for further research and experimentation with natural resource accounts that measure the impairment of natural and environmental resources and provide, for example, a "sustainable development profit and loss statement based on sustainable development accounting principles" or an environmentally adjusted "value added statement" Macve and Carey, , p. Moreover, uncertainties and measurement difficulties have not inhibited accountants from reporting intangibles that companies do benefit from, such as research and development, brands, and goodwill, when user demands or management requirements and incentives have been sufficiently strong Arnold et al.

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## Chapter 2 : Executive Report: Measuring & Valuing Environmental Impacts

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Also, click here to watch a special video on the cost of poor quality published by the ASQ Audit Division. The costs associated with providing poor quality products or services. There are four categories: Having such information allows an organization to determine the potential savings to be gained by implementing process improvements. Quality-related activities that incur costs may be divided into prevention costs, appraisal costs, and internal and external failure costs. Prevention costs Prevention costs are incurred to prevent or avoid quality problems. These costs are associated with the design, implementation, and maintenance of the quality management system. They are planned and incurred before actual operation, and they could include: Product or service requirementsâ€”establishment of specifications for incoming materials, processes, finished products, and services Quality planning â€”creation of plans for quality, reliability, operations, production, and inspection Quality assurance â€”creation and maintenance of the quality system Trainingâ€”development, preparation, and maintenance of programs Appraisal costs Appraisal costs are associated with measuring and monitoring activities related to quality. Verificationâ€”checking of incoming material, process setup, and products against agreed specifications Quality audits â€”confirmation that the quality system is functioning correctly Supplier ratingâ€”assessment and approval of suppliers of products and services Internal failure costs Internal failure costs are incurred to remedy defects discovered before the product or service is delivered to the customer. These costs occur when the results of work fail to reach design quality standards and are detected before they are transferred to the customer. Wasteâ€”performance of unnecessary work or holding of stock as a result of errors, poor organization, or communication Scrapâ€”defective product or material that cannot be repaired, used, or sold Rework or rectificationâ€”correction of defective material or errors Failure analysisâ€”activity required to establish the causes of internal product or service failure External failure costs External failure costs are incurred to remedy defects discovered by customers. These costs occur when products or services that fail to reach design quality standards are not detected until after transfer to the customer. These costs must be a true measure of the quality effort, and they are best determined from an analysis of the costs of quality. Such an analysis provides a method of assessing the effectiveness of the management of quality and a means of determining problem areas, opportunities, savings, and action priorities. Cost of quality is also an important communication tool. Philip Crosby demonstrated what a powerful tool it could be to raise awareness of the importance of quality. Many organizations will have true quality-related costs as high as 15 to 20 percent of sales revenue, some going as high as 40 percent of total operations. A general rule of thumb is that costs of poor quality in a thriving company will be about 10 to 15 percent of operations. Effective quality improvement programs can reduce this substantially, thus making a direct contribution to profits.

## Chapter 3 : Best Environmental Software | Reviews of the Most Popular Systems

*Measuring & Managing Environmental Costs - Professional Series [Thomas Klammer, Shahid Ansari, Janice Bell, Carol Lawrence] on blog.quintoapp.com *FREE* shipping on qualifying offers.*

Ruch As important as productivity is to the continued economic development of the world, it is surprising that so little is known about measuring and managing it. Part of the problem may lie in the unit of analysis industry uses to measure productivity and in a failure to recognize the complexity of the relationships between the productivity of the individual worker and the total performance of the organization. The body of research knowledge provides little help. A multitude of micro studies of individual work behavior exist, but the measure of productivity used is seldom comparable to those developed in industry. Organizational studies generally focus on the total performance of the organization, but even those that are centered on organizational productivity rarely attempt to disaggregate findings to the business unit, work group, or individual level in any systematic way. Within the organization, individual workers performing specific jobs form the base level for all productive endeavor. In modern, complex organizations, however, the linkage between individual productivity and the productivity of organizational systems becomes blurred. For a variety of reasons, the linkages are seldom one to one. Only by understanding the individual level of productivity, however, can practitioners and researchers begin to build the theories and models that deal with the dysfunctions Page Share Cite Suggested Citation: Understanding the Productivity Paradox. The National Academies Press. It is important to note at the outset that focusing on individual productivity measures provides a myopic view of the organizational world. Organizations are set in the context of a changing, competitive environment in which strategies are developed to guide the efforts of management and workers toward a common vision and set of objectives. Even the best-designed processes will fail without a supportive culture within the organization that values change, continuous improvement, goal commitment, group cohesion, and respect for people. Every concept in this chapter assumes that the individual worker and the work group are set in an organizational context that is internally consistent and environmentally consonant. It is also important to note that productivity, although a major concern, is not the only indicator of individual or organizational performance. Productivity interacts with other aspects of employee performance, financial controls, innovation, and competitive effectivenessâ€”any one of which can lead to organizational failure. In Chapter 6 Sink and Smith identify seven related but separable performance criteria for an organizational system: Other authors, such as Pritchard Chapter 7 and Campbell Chapter 8 , have slightly different ways of relating or combining these performance dimensions. For the purposes of this chapter, my definition of productivity includes effectiveness producing the right products or services , efficiency prudent utilization of resources , and quality meeting technical and customer specifications. My purpose in this chapter is to assimilate knowledge about the measurement and management of individual productivity in order to provide a link in the chain of understanding regarding how individual productivity contributes to group productivity, which in turn contributes to organizational productivity. My intent is to aggregate existing knowledge and propose some theoretical foundations in order to reveal areas in which theory development and empirical research are needed. Throughout, I make an effort to bridge the gap between the concerns of researchers and the needs of practitioners in industry. Page Share Cite Suggested Citation: The measurement system provides an implicit definition of productivity for the operation. It communicates to the worker, the supervisor, and others the common expectation from the task. The productivity measurement provides specific direction and guides the worker toward productive activities. Monitor performance and provide feedback: The measurement system provides a means to check progress toward an objective. Productivity analysis, particularly the examination of trends, helps identify problems before they become crises and permits early adjustment and corrective action. Like any other indicator, productivity measurements do not necessarily identify the source of the problem, only that one exists. Facilitate planning and control: Productivity measurement provides information on costs,

time, output rate, and resource usage to allow decision making with respect to pricing, production scheduling, purchasing, contracting, delivery scheduling, and many other activities in the industrial cycle. Productivity analysis, together with other elements of a competitive strategy, may determine which products or processes should be expanded and which should be phased out. Productivity analysis, combined with cost data, aids in the evaluation of proposed changes to existing products or processes and the introduction of new ones. It is one of the primary foundations for the continuous improvement efforts that are both popular and necessary for survival in business firms today. The purpose of the measurement system is critically important in determining the specific measures to be used. For example, if the measures are to be used only for planning and control purposes, the inputs into the measures and the outputs may be imprecise aggregate figures that provide guidance for setting schedules and future capacity requirements. If, however, the measures will be used as a basis for an employee evaluation system leading to bonuses, pay raises, layoffs, and disciplinary actions, inputs and outputs of the measures must be more precise and accurate for shorter time periods, and they must exclude factors outside the control of the worker. Questions of equity and interaction among individual jobs become evident. The functions of monitoring performance and providing feedback, diagnosing problems, facilitating planning and control, and supporting innovation are common to many types of measures, and productivity is no exception. The function of defining productivity and directing behavior, however, warrants more explanation because it is important to Page Share Cite Suggested Citation: A simple example of a waiter in a restaurant can be used to explain how measures of productivity can direct behavior. If the measure of productivity is customers served per hour, the emphasis is on speed and throughput, and the waiter will try to complete each transaction as quickly as possible. On the other hand, a measure of dollars of food served per customer would lead to totally different behaviors; the waiter would suggest more expensive items and would encourage the customer to have appetizers, wine, and dessert, regardless of the time taken. In this case, time is not a factor; the quick turnover of customers would be a disadvantage. Other possible measures could each lead to a different set of behaviors. One way to view individual productivity is to consider how the efforts of an individual contribute to the productivity or success of the organization. Whether the actions of the waiter in each of the examples above would be productive or counterproductive depends on the type of restaurant and, specifically, its goals and objectives. A downtown delicatessen would have one set of goals and circumstances; speed in serving customers would be a distinct advantage. A fine restaurant in the suburbs would operate in a different milieu; speed in this case could be a detriment. The fundamental question is not, what productivity measures should be used? The fundamental question is, what are the organizational objectives? The secondary question is, what set of individual productivity measures will direct the behavior of employees to meet those objectives as they work toward their own personal goals? The aim of the organization is to align work behavior with organizational goals. It is the responsibility of management, therefore, to develop measures that will elicit organizationally desirable behaviors. These relationships are illustrated in the model shown as Figure Werther et al. The law of effect, the cornerstone of operant psychology, says that behavior is a function of its consequences; positive outcomes reinforce behaviors, which leads to their being repeated and expanded. Simply establishing a measure and feeding back the results to the employee can be regarded as a form of reinforcement; employees tend to work on the basis of the measure in any circumstances. If there is a net incentive for high performance, the link between behavior and the measure will be stronger. The greater the incentive, the stronger the relationship between the two. The term net incentive indicates that many incentives and disincentives may operate in a given set of circumstances. Worker motivation is a complex issue; in taking all of that complexity into consideration, the model suggests that the net incentive should be positive and tied to performance. Unfortunately, many organizational incentive systems are based on productivity or other performance measures that are not in line with organizational goals. Programmers, for example, may be measured and rewarded for lines of code written per hour. Accountants may be evaluated on the number of reports produced, and maintenance personnel on the number of routine equipment overhauls performed. In each instance and many more , maximization of the measured criterion

would likely be counterproductive to the organization. Following the same logic, the productivity measurement system at each level of analysis should be developed to direct behaviors and performance at one level of the organization to the goals at the next higher level. These relationships are depicted in their ideal state in my Goal Alignment model, Figure  Across the top of the model, the organization attempts to make business unit goals at all intermediate levels congruent with organizational goals. Productivity measures at the individual or group level direct behaviors to the business unit goals, if properly aligned. That is, the individuals or groups will work to the measures; it is the responsibility of the organization to ensure that the measures are in line with the goals. Reading horizontally across the bottom of Figure , the model indicates that the productivity performance of a business unit is a direct function of the productive behavior of each of the individuals and groups within the unit. In turn, organizational productivity is a function of the productivity of each of the units. The degree to which this is true depends on the definition of productivity at each level and the interactions among the elements. Also, in this ideal model, the individual or group productivity results would sum to the productivity of the next higher business unit and ultimately to the productivity of the organization. At the business unit level, managers will direct activities, allocate resources, and make other decisions to maximize performance as specified in the measurement system especially if rewards are tied to performance. At each intermediate level of analysis, therefore, productivity measures should be selected and positioned such that the performance of the unit directly contributes to the goals at the next higher level. The Goal Alignment model suggests that individuals, groups, and business units are not goal driven, but measurement driven. It is one thing for a firm to establish and communicate goals. It is quite another to devise and implement measurement systems that can be maximized only by behavior and performance that lead directly to goal accomplishment. Organizations are real, not ideal. The Goal Alignment model, as well as many of the other models and concepts in this chapter, represent targets toward which organizations should strive. The degree to which they can achieve these targets, resolve the related issues, and design perfect productivity measurement systems determines their probability of survival and success. Researchers can help in this effort by empirically testing the relationships suggested in the Goal Alignment model. Attempts to amalgamate all of that knowledge into a comprehensive, unified theory of individual productivity would likely prove fruitless. What is needed is a framework that will provide guidance for theory development, model building, empirical studies, and other forms of research. One such framework is the separation of the factors affecting individual productivity into five distinct, but interacting, sets of variables: Each of these sets of variables involves one or more disciplines; together they approach the boundaries of the body of knowledge of work. Obviously, they overlap and interact. But somewhere within the complex interactions of all of these variables lie the determinants of individual productivity. Development of a comprehensive theory of individual productivity is too much to ask, but perhaps it can be approached as would building a cathedralâ€”one stone at a time. To develop a theory or build a cathedral, one needs plans and models. In this section, I discuss two models of individual productivity that encompass a wide range of variables. Adapted from Ruch and Hershauer  They categorized the variables as primary factors, secondary factors, individual factors, organizational controllables, individual and organizational demographics, and bodies of knowledge or files of information. In this section, I use a revised and greatly simplified version of their model see Figure as a basis for explaining the principal influences on the productivity of the individual worker. In this Conceptual Productivity model, productivity is a function of four major factors: Taken together, the first two factors establish the potential productivity of the task.

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## Chapter 4 : Supply-chain sustainability - Wikipedia

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Enhanced image with public, regulators, lenders, investors Employee awareness of environmental issues and responsibilities EMS under ISO Figure 1: The continuous improvement cycle. An EMS encourages an organization to continuously improve its environmental performance. The system follows a repeating cycle see figure 1. The organization first commits to an environmental policy, then uses its policy as a basis for establishing a plan, which sets objectives and targets for improving environmental performance. The next step is implementation. After that, the organization evaluates its environmental performance to see whether the objectives and targets are being met. If targets are not being met, corrective action is taken. The results of this evaluation are then reviewed by top management to see if the EMS is working. Management revisits the environmental policy and sets new targets in a revised plan. The company then implements the revised plan. The cycle repeats, and continuous improvement occurs. The policy is the foundation of the EMS. Planning - An organization first identifies environmental aspects of its operations. An organization then determines which aspects are significant by choosing criteria considered most important by the organization. For example, an organization may choose worker health and safety, environmental compliance, and cost as its criteria. An objective is an overall environmental goal e. A target is a detailed, quantified requirement that arises from the objectives e. The final part of the planning stage is devising an action plan for meeting the targets. This includes designating responsibilities, establishing a schedule, and outlining clearly defined steps to meet the targets. Implementation - A organization follows through with the action plan using the necessary resources human, financial, etc. An important component is employee training and awareness for all employees. Other steps in the implementation stage include documentation, following operating procedures, and setting up internal and external communication lines. Evaluation - A company monitors its operations to evaluate whether targets are being met. If not, the company takes corrective action. Review - Top management reviews the results of the evaluation to see if the EMS is working. The plan is then revised to optimize the effectiveness of the EMS. The review stage creates a loop of continuous improvement for a company. Contact Us to ask a question, provide feedback, or report a problem.

## Chapter 5 : Learn About Environmental Management Systems | Environmental Management Systems (EM

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Abstract Coffee is a major international commodity, and because of this, coffee production has the potential for considerable global impacts on the environment. These impacts can include the consumption of energy, water, land and the loss of native forest. Here we quantify these costs using Costa Rica as a case study, and describe an initiative undertaken at the Montes de Oro Cooperative in which these impacts are reduced substantially through the development and application of alternative technologies. We show how these processes reduce the consumption of resources, and also reduce economic costs to the farmer, thus providing a market-based incentive for conservation. The initiatives undertaken at Montes de Oro can provide a model for the future, for reducing the environmental costs of coffee production, while simultaneously improving the economic conditions of the people in coffee producing regions. There has been substantial discussion of the environmental costs of coffee production, although this discussion has focused primarily on coffee cultivation and its contribution to the displacement of natural habitats and communities Rappole et al. Less attention has been given to the potentially important costs of coffee processing. Coffee processing as traditionally practised consumes substantial amounts of energy, water and space, and this consumption can have potentially significant impacts on native tropical biodiversity. In this article we quantify these costs of conventional coffee processing in Costa Rica, and then present alternative coffee processing technologies that have been developed at the Montes de Oro Cooperative to mitigate these impacts. We show how these alternative technologies consume a fraction of the energy used by conventional coffee processing, and whatever energy is consumed is produced using renewable sources such as solar power or co-generation. Furthermore, we describe how these technologies reduce the consumption of water and space, and finally describe a novel method of coffee cultivation that substantially reduces the impacts of growing coffee on the loss of forest-associated species. Because these novel processing technologies and methods for cultivation provide economic benefits to farmers, as well as reduce the ecological impacts, they represent a potentially effective market-based mechanism for conservation in the coffee-growing regions. Energy Consumption and Coffee Processing Conventional coffee processing is energy intensive. After coffee is picked, the pulp and mucilage must be removed, which requires two separate processes. Then the coffee must be dried and the parchment removed, and finally the coffee must be sorted. The remaining demand is used for the other processes depulping, washing, sorting, etc. The energy consumption and energy costs associated with coffee drying are uniform throughout Latin America, as the same equipment design is used throughout the region, and electricity costs are linked to the world oil prices. The cost of firewood to provide thermal energy is also fairly uniform and to a large part influenced by the diesel prices for transportation MDI field surveys  Conventional coffee drying consumes on an average  Assuming a net export of ,, lbs of green coffee annually ICAFE and the rates of electrical energy consumption from [Table 1] , coffee drying in Costa Rica consumes on the order of 25,, kWh of electricity enough to power a community in Costa Rica of some 13, people [UNDP ]. These energy costs impose a financial burden on small farmers, and savings on electricity costs provided by solar driers increases the viability of small coffee operations, which otherwise could be converted to other types of land use with lower ecological value, such as cattle production, commercial development or housing. In addition to electrical energy, coffee drying in Costa Rica consumes approximately , cu. Based on an extrapolation of the amount of fuel wood consumed for the drying process ICAFE , we estimate that throughout Mesoamerica, approximately 6, hectares of forest are cut to supply the firewood used to dry the coffee harvest each year. This is roughly equivalent to 3 sq. Thus, reducing the amount of wood used for drying coffee could make a significant contribution to tropical forest conservation. The Montes de Oro Cooperative has reduced their energy consumption dramatically through the development and implementation

of new technologies. This is a hybrid system that uses a combination of solar thermal and biomass gasification to dry coffee beans in a vertical, tower-like, natural convection drying chamber [Figure 1]. The coffee flow inside the chamber is controlled by moving trays that cycle through the tower during the approximately hour drying period. The thermal energy required for drying is supplied by solar thermal collectors during the day, and the gasification of coffee husks see a little later in the article is carried out at night or during rainy periods. Energy conservation will be further realized at Montes de Oro through the practise of co-generation, using waste products from coffee production to produce electricity through a thermo-chemical gasification process that is currently operational at Montes de Oro. For gasification, coffee parchment is collected and gasified by a thermo-chemical reaction called pyrolysis, in which the carbohydrates of the parchment are broken down to their fundamental molecular components. A gaseous mixture of hydrogen, carbon monoxide and oxygen are the main components of the so-called producer gas, which is a fuel that burns similar to natural gas or propane, although with a lower energy content. Water Consumption and Coffee Processing Conventional coffee processing uses large quantities of water to remove the outer pulp and mucilage and transport the waste products. On an average, these processes use between 1,, liters of water per lbs of green coffee ICAFE  At Montes de Oro the consumption of water has been reduced by the adoption of a fully mechanized process in which the fruit or pulp of the cherry and the mucilage surrounding the bean is mechanically separated from the bean by friction. This differs from the conventional "washed coffee" in which the pulp is removed mechanically and the coffee is fermented in concrete tanks to remove the mucilage. In addition to the obvious advantages of conserving water, this process has two other important advantages in terms of less land area and reduction in construction costs. With the "semi-washed" mechanical method, the water that is used has a higher concentration of sugars and other organic matter, and thus is suitable for use in the production of biogas. This contrasts with the more diluted product resulting from conventional "washed" processing, which cannot be used to generate biogas. Secondly, because less water is used, the settling ponds do not have to be as large as conventional settling ponds. This reduces construction costs, which can be considerable, as well as the need for land, which is also expensive. Coffee Cultivation and Forest -Associated Species A final cost caused by coffee cultivation that has received a lot of attention is the displacement of native forest by coffee cultivation. The loss of forest and the potential loss of native biodiversity resulting from coffee cultivation and processing is substantial. On account of the great extent of land under coffee cultivation, as well as studies reporting high species diversity of multiple taxa in shade versus sun coffee Perfecto et al. Although preferable to sun coffee in terms of the preservation of tropical rain forest biodiversity Greenberg et al. These include the loss of resident tropical species that depend on primary forests because many of the important habitat features typical of mature forests, such as lianas, bromeliads and large trees, are under-represented or absent in all but the most rustic coffee plantations Rappole et al. At the Montes de Oro Cooperative, a new system has been developed for coffee cultivation that maintains native forest without sacrificing yields. This system is termed "Integrated Open Canopy" or "IOC" Coffee Arce , in which coffee is planted in ha patches with varying amounts of shade, depending on local conditions, but typically too little to qualify for shade coffee certification. Coffee patches are surrounded by an equivalent amount of forest. A typical parcel within the cooperative would be ha in size, which would result in units of production consisting of ha coffee and ha of forest. The important feature of this system, from a standpoint of biodiversity, is that it maintains forest habitat for species that do not use shade coffee plantations. To test the potential for IOC to support forest-associated species not found in shade coffee plantations we sampled birds in seven sites each in IOC plantations, shade coffee plantations and primary forests, from December to February and , using standardised mist netting Karr  Each site was sampled once for three consecutive days with 10, m long nets placed in a grid 25 m apart. We captured 2, individuals representing species during 6, net hours. We did not analyse species richness of the generalist species separately because they were not of conservation concern Rappole et al. Species richness of all species combined was similar in shade coffee and IOC coffee plantations; however, IOC coffee farms supported higher numbers of forest-associated species than shade farms [Figure 2]. Nonetheless, the number

of forest-associated species in IOC farms was significantly lower than in primary forest sites, probably because IOC samples included younger forest, as well as nets in coffee. IOC coffee production also offers important economic benefits to farmers. First of all, the more open conditions result in greater yields. Higher yields in IOC are attributable to a number of factors. IOC coffee is generally subject to lower levels of disease because producers have the option to create conditions of high illumination, which is known to discourage coffee leaf spot disease Mycena citricola; Avelino et al. The protecting adjacent forest can also increase yields because many coffee pollinating insects depend upon forests for nesting habitat Ricketts et al. Forest buffers in IOC coffee also serve to protect coffee plants from wind damage Harvey et al. Finally, in cases where forest areas are being allowed to regenerate, they can qualify for carbon credits under the Kyoto Protocol. As IOC coffee provides economic benefits to farmers while contributing to the conservation of native forest, it represents another example of a market-based conservation incentive developed at Montes de Oro. Conclusion The initiatives undertaken at the Montes de Oro Cooperative can substantially reduce the consumption of resources associated with the processing and production of coffee. These activities provide a model for the future, for reducing the environmental costs of coffee production, while simultaneously improving the economic conditions for the people in coffee-producing regions, and providing incentives for individuals to engage in agricultural practices that conserve natural resources and biodiversity.

## Chapter 6 : Measuring environmental impact

*Report Measuring and Managing the Environmental Cost of Coffee Production in Latin America Victor Julio Chavez Arcea, Raul Raudalesb, Rich Trubeyb, David I. Kingc,#, Richard B. Chandler d and Carlin C. Chandler.*

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