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PAPER 3: A CONCEPTUAL MODEL OF ENVIRONMENTAL ACCOUNTING FOR INDIVIDUAL FARMS

Kent Olson and Stefano Destro

Center for International Food and Agricultural Policy
University of Minnesota
1994 Buford Avenue, 332 C.O.B.
St. Paul, Minnesota 55108-6040 U.S.A.
Phone: (612) 625-8713
FAX: (612) 625-6245

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A Conceptual Model of Environmental Accounting for Individual Farms[1]

Kent Olson and Stefano Destro[2]

Over the past 20-25 years, traditional measures of agricultural productivity show remarkable improvement. The proportion of people employed in this economic sector has never been so low as it is now. There is also a decline in the consumption of resources per unit of product.[3]

However, these are traditional measures of production and productivity. There is a major concern over society's impact on the environment and the environment's ability to be able to sustain life in the future. This concern has manifested itself in words, actions, and studies. Sustainable development and sustainable agriculture are just two of the terms that have become part of the language used in the current movements to protect the earth. Actions have been at the extremes from Green Peace's direct action approach to international efforts, e.g., the Rio conference of a few years ago and the concerns over environmental issues in NAFTA and GATT.

For the most part, previous studies of the impact of sustainable agriculture have estimated only the change in traditional measures of farm income.[4] Some studies have estimated the change in environmental measures to protect the environment. With the exception of Faeth (1993) and Faeth et al. (1991), these studies have not placed a value on the environmental change. The studies have made either an explicit or implicit judgement of whether the impact on the environment is worth the change in profit. The question they seem to be asking is whether the farmer can maintain a certain income level and still make

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[2]Olson is in the Department of Agricultural and Applied Economics, University of Minnesota; Destro is in Dipartimento Territorio e S.A.F., Sez. 2, Universitá degli Studi di Padova.

[3]As a result some Dutch researchers have estimated a surplus of between 40 and 80 million ha in Europe by the turn of the century (WRR).

[4]For an introduction to this literature, the reader is referred to two journals (American Journal of Alternative Agriculture and the Journal of Sustainable Agriculture) and to these papers: Fox (1991), Faeth (1993), Dobbs (1994), and Roberts and Swinton (1994).

a change which is seen as good for the environment. That is, the authors have made a qualitative judgement of degree of "goodness" of the physical side of the change; they consider a change as better because it uses less energy, uses fewer pesticides, causes less erosion, etc. However, with the exception of Faeth, these studies have not valued the physical changes so that an equal comparison can be made.

Castle (1994) provides three classifications of the analytical approaches to studying sustainability: (1) maintaining capital, (2) capacity building, (3) sequential adjustments. Castle held that the third method (which he called "uncertainty and disequilibria") was needed because of the uncertainty of the future and the basic inability to maintain perfectly the environment as we know it now (or as we knew it as some point in time). He argued that what we need is the ability to be flexible and the ability to make sequential adjustments. Kirschermann (1993) stated this idea in different words: sustainability is not just survival and to continue; it is durability with some kind of quality. Kirschermann also said we need to work with nature but we also need to realize that nature changes; our goal should not be to return to a pristine notion of nature. He argued that to ask what nature was doing before agriculture is the wrong question; the right question involves what nature is doing now where we are trying to farm.

Kirschermann argued that profitability needs to be viewed in the long-run, not annually and that some economic models are outmoded just like some physical models. What is needed is a new economic model that incorporates both the traditional measures and new measures of the value of nature. At the national level, environmental accounting has been proposed to show how nations use their natural resources and the resulting change in the wealth of the nation. At the farm level we need to take these ideas and develop a set of accounts which we can use to see how different farming methods affect both the traditional measures of income and asset values as well as how a farm's assets are used.

The Conference of Rio (Chapter 10) also puts emphasis on the land use issues: "Land is normally defined as a physical entity in terms of its topography and spatial nature; a broader integrative view also includes natural resources: the soils, minerals, water and biota that land comprises. These components are organized in an ecosystem which provides a variety of services essential to the maintenance of the integrity of life-support systems and productive capacity of the environment. ... Expanding human requirements and economic capacity activities are placing ever increasing pressure on land resources. ... If, in the future, human requirements are to be met in a sustainable manner, it is now essential to resolve these conflicts and move towards more effective and efficient use of land and its natural resources" (United Nations, 1992a).

The objective of this paper is to provide a framework of accounting to allow the evaluation and comparison of both conventional and traditional agriculture by accounting for both traditional market transactions and the environmental resources and changes in those resources. Even if a study estimates the value of the change in the resource inventory, the connection to the farmer's financial condition is not made in an explicit way. Again, the study by Faeth et al. makes a strong contribution to the need to have such an accounting system for farms. Farmers should be interested in this information because it is their own backyard where they are working, living and using their own assets. We start with a brief review of the work done with national accounts and then move to accounting on individual farms.

ACCOUNTING FOR THE ENVIRONMENT IN NATIONAL ACCOUNTS

For a long time, most economists did not pay close attention to the role played by the environment in economic activities. The environment had been considered as a source of raw materials and a sink to receive the residues of the production and consumption process. Thus, the common economic indicators that economists and politicians use to analyze the performance of their economies are not designed to detect the qualitative and quantitative variations of the natural resource. Such a System of National Accounts (SNA) reflected the Keynesian macroeconomic model that was dominant when the system was developed (Repetto, 1989). Keynes and his contemporaries were facing the Great Depression so that a scarcity of natural resource was marginal.

Since the SNA is a tool for economists and politicians, the system reflects somewhat the contents of the economic theory for which it works.[5] The new concept of Sustainable Development and the underlying economic assumption need a more powerful and comprehensive standard of national account as well as new standards for regional and individual accounting. "Where the [1968 SNA] accounts are wrong, in the sense that the accountant's income contains elements of capital

[5]According to Dasgupta (1990) the interest in resource economics, more particularly environmental economics, has just been intermittent, and if we are currently witnessing a resurgence, we have also just lived through a decade-long neglect, during which much valuable work could have been done.

(representing running down stocks of natural resources or polluted air or water), such "income" exaggerates true income, and if consumed, could lead to inevitable ruin. In other words, accounting would be encouraging behavior that cannot be sustained." (Salah El Serafy, 1991). Furthermore, we have to consider that incorrect income measurement can lead to faulty economic policies as well as over consumption.

One of the first experiences in a new accounting system is the Net Economic Welfare (NEW) proposed by Nordhaus and Tobin (1973). The NEW takes into account the non-marketed goods and services like the "do it yourself", the work of volunteers, and so forth. However, this method paid little attention to the environmental issues because in the early 70s this problem was not considered to be as important as it is nowadays.

According to Peskin and Lutz (1990), the early work on incorporating the environment into accounting can be classified into four approaches. The first approach deals with the cost of pollution-abatement which characterizes the US policy. The second approach accounts for flows of and changes in the stock of natural resources. This is the French and Norwegian method. This is a very complex method that requires a huge quantity of data, but the information it generates could be very useful for environment and economic policy. The third approach has been developed by Repetto and associates at the World Resource Institute. The core of the method is the subtracting out the value of natural resource depletion from GNP and NNP. They applied this method to Indonesia, China, and Costa Rica. Finally, the fourth approach attempts a comprehensive and integrated resource and economic accounting in both physical and values terms (United Nations Statistical Office and Peskin's approaches).[6] Some of these methods deal with the accounting system as a whole, others focus on a particular issue (for instance Repetto, Leipert). Others are field experiments which have dealt with the collection of data and with the valuations. These field experiments demonstrate that it is already possible to build a new accounting system, even in a developing country with little information.

The United Nations' System of National Accounts (SNA) was first developed in the 1950s (United Nations, 1992, p.20). Until 1993, the most recent version of the SNA was published in 1968 (United Nations, 1968). Even though the 1968 SNA did include natural assets to some degree, Harrison (1993) says the problem

[6]For a comprehensive review of environmental accounting systems see: Peskin and Lutz (1993); UN (1992b); and Franz and Stahmer (1993).

was that the SNA did not see the environment as a separate dimension to the SNA and thus did not fully account for the use of natural assets. Other work in the 1970s and 1980s (e.g., United Nations Statistical Office 1977, World Bank 1989) have laid the groundwork for accounting for natural asset use. The most recent SNA (Inter-Secretariat Working Group on National Accounts, forthcoming) does not include natural assets in the national accounts explicitly but does include a discussion of how to include the use of natural assets as a satellite or supplement to the national accounts.

In addition to the work at the United Nations and the World Bank, many countries have undertaken on their own projects for new national accounting. Some of them are based on physical accounting (i.e. inventory); others on monetary evaluation (Repetto 1989; Leipert 1989; INSEE 1987; Archambault 1988; Garnasjordet and Saebo 1986; Carlucci and Giannone 1990; Daly 1990). Cabe and Johnson (1990) discuss how natural resource accounting can be used in policy modeling and particularly in USDA's resource appraisal under the Soil and Water Resources Conservation Act of 1977.

As Lutz (1993) points out, what the national accounts need is the ability to move beyond the traditional gross domestic product (GDP) and the net domestic product (NDP) to an environmentally adjusted net domestic product (EDP) and an environmentally adjusted net income (ENI). The traditional GDP measures do not account for the depletion of natural resources which can increase income but it does count the expense of cleaning up or restoring natural assets damaged as a result of production or other activity; that is, GDP exaggerates true production by not counting all costs and by counting costs of restoring assets. This problem is analogous to not counting machinery depreciation as an expense but adding the expense of machinery replacement as part of national income. NDP is better since it is a net measure of production, but it still lacks the full accounting of the use of and impact on the environment. As Lutz points out, measures such as EDP and ENI "would better identify true income, better capture environmental services, account for the depreciation of both man-made and natural capital, exclude relevant categories of defensive environmental expenditures, and estimate damages as a result of economic activities." (p.2)

In the 1993 SNA, assets are classified as produced (e.g., buildings, machinery, livestock, orchards, etc.) or as non-produced (e.g., land, surface water, minerals, ground water, etc.) (Lutz 1993). Bartelmus, Stahmer, and van Tongeren (1993) develop a System for Integrated Environment and Economic Accounting (SEEA) as a framework for an SNA satellite system. The SEEA is proposed as a satellite or supplement to preserve both the integrity of the original SNA and to allow countries to continue to track their progress and condition over time by the same measures and start to follow how their economies are using the environment. While the SNA relies on market price information to value income and assets, the SEEA requires more estimates and imputations in near-market and nonmarket conditions. The costs of the depletion of natural resources (as well as the depreciation of produced capital) and the costs of the degradation of natural resources are deducted from NDP to obtain EDP. The ENI can be obtained by adjusting EDP for damages to natural resources that are unrelated to production activities -- such as, expenditures on environmental protection, effects on health, transfer of environmental damages between countries, etc.

APPLICATIONS TO INDIVIDUAL FARMS

In this section, we discuss how the procedures developed for national accounts can be adapted for use on individual farms. Similar to the SNA, we describe a set of satellite or supplemental accounts to account for the use of natural resources. These supplemental accounts will allow farmers to continue to track their performance and condition with the traditional measures as well as to see the impact on and of the environment. A full integration of the environment into the accounting system may cause farmers to reject the new system and, thus, not see the environmental effects.

Conceptual Issues.

Analogous to the national accounts, the need at the farm level is the ability to adjust the traditional net farm income (NFI) and net worth (NW) to obtain environmentally adjusted net farm income (ENFI) and net worth (ENW). These adjustments should include only the private, on-site costs and benefits since that is what the farmer will see as a private citizen. This approach also could be extended to include the social, off-site impacts of using natural resources to obtain social and environmentally adjusted net farm income (SENFI) and net worth (SENW), but we leave that to another paper.

The traditional farm accounting frameworks (exemplified in the balance sheet and income statements) currently used by many farmers fit the farmers' private and immediate financial perspective only. In such frameworks, there is only some evidence of the value of the changes in natural assets. For example, asset values will be lowered due to severe and sudden erosion which destroys the ability to cultivate land, but there is no trace of adjustments made due to changes in soil productivity caused by gradual erosion. Because of this shortcoming, current accounts are unable to measure the sustainability[7] of present systems of crop production. "Thus, soil can be eroded, groundwater contaminated...all in order to support current agricultural practices and income. No depreciation allowance is currently applied against that income for the degradation of the natural assets, even though future income levels are jeopardized. Current accounting practices can mask a decline in wealth as an increase in income, i.e., 'living off your capital'" (Repetto, et al. 1989).

Farmers are aware of the depreciation of their tractor, because they have to pay rising repair costs and because the market value of their tractors goes down year by year. Unfortunately, farmers do have not the same perception concerning their land.[8] The depreciation of soil due to gradual erosion is a hidden cost and, of course, a noncash cost. So it is not easy to see.

To improve our eyesight, we propose adding a set of accounts to the traditional balance sheet and income statement to account for the use and contribution of natural assets. Since the specific formats of these two statements vary both between countries and between institutions, we start with the final measures in each: net worth and net farm income. The formulas and definitions may differ for these measures, but if we start from what each farmer understands and adjust for environmental use, farmers will better understand the impact of resource use on their farm.

For the balance sheet, we start with the traditional net worth (NW). Resource use may cause net worth to decrease due to either depletion or degradation of that resource. While the difference between what is depletion and what is degradation may seem both obvious and uncertain, the distinction is

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[7]Definitions of sustainability has been given by several authors. We'd like to quote a definition by Costanza, Daly and Bartholomew (1991): "... the amount of consumption that can be continued indefinitely without degrading capital stocks-including natural stocks."

[8]Such a natural capital can be regarded as a series of elements (soil, weed, fungi, bacteria, and so forth) and their relationships. The importance of the relationships is not less important than the elements, hence we should, at least from a theoretical point of view, evaluate any change in the composition of the agroecosystem.

useful both conceptually and in choice of valuation method (which is discussed in the next section). The depletion of natural assets due to production activities include the draining of an aquifer, the selling or use of on-farm assets (e.g., minerals, sand, trees), etc. Some systems and farmers already may account for the depletion of natural assets in the traditional estimation of net worth, especially rapid depletion. Obvious and rapid depletion (such as sales) should be included in the traditional accounts. Less obvious or nonmarket depletion (such as gradual aquifer use) should be included in the supplemental accounts, as shown below. The degradation of natural assets (such as the polluting of water and soil) should be included in the supplemental accounts. If productive activity increases the value of a natural asset (e.g., a fallow year or green manure production), that increased value should be part of the supplemental accounts. In the adjustment of the net worth, the accumulated values are used since the balance sheet is an estimation of the asset values at a particular point value; that is, the balance sheet contains the value of the stock of produced and natural assets; the income statement contains the value of the flow of services from those assets. The adjustment of the traditional net worth is as follows:

(Traditional) Net Worth (NW)
- accumulated depletion of natural assets
  (if not accounted for in the traditional NW already)
- accumulated degradation of natural assets
  (if not accounted for in the traditional NW already)
+ accumulated improvement of natural assets
= Environmentally adjusted net worth (ENW)

The income statement is adjusted in a similar way. As with machinery depreciation, the depreciation of natural assets needs to be subtracted from income to estimate the environmentally adjusted net income. This "depreciation" of natural assets is both depletion and degradation as used in the balance sheet. Any increase in value of an asset should be counted as income. In this adjustment of net farm income, the values of the resource depletion, degradation and improvement should be the flow of use or improvement occurring during this particular period (usually one year) -- not the total degradation, for example, which has occurred over many years which is included in the balance sheet. The adjustment of the traditional net farm income is as follows:

(Traditional) Net Farm Income (NFI)
- depletion of natural assets
- degradation of natural assets
+ improvement of natural assets
= Environmentally adjusted net farm income (ENFI)

Faeth et al. (1991) use an approach similar to our proposal when they compare net farm income with and without Natural Resource Accounting (NRA); but we believe their approach is incorrect from a farmer's perspective. Their example from Pennsylvania compares the per acre costs and returns for a conventional corn-soybean rotation. The soil depreciation allowance is an estimate of the present value of future income losses (both on-site and off-site) due to the impact of crop production on soil quality. Faeth et al. format the income statement in this way:

	w/o NRA	w/NRA
+ Gross operating margin	45	45
- Soil depreciation	-	25
Net farm operating income	45	20
+ Govt. commodity subsidy	35	35
= NFI	80	55

The system used by Faeth et al. has a national perspective even though it is applied to an individual farm. They are trying to show society's benefit or loss of having production take place on this one acre. Hence, they include both on-site and off-site impacts of soil erosion. In addition, they (correctly) state that government subsidies should not be counted from society's viewpoint because subsidies are a transfer from one segment of society to another.

Most farmers, however, in their private accounting, do receive the government payment, and they do not see (or are not held accountable for) the off-site damages. Using Faeth et al.'s numerical example, our proposed framework produces this income statement:

	w/o NRA	w/NRA
+ Gross Operating Margin	45	45
+ Govt. Commodity Subsidy	35	35
= Traditional Net Farm Income	80	80
- Soil Depreciation	-	25
= Net Farm Income	80	55

The traditional net farm income measures a profit of \$80. This ignores the soil depreciation of \$25. The net farm income with NRA is \$55. Since Faeth et al.'s soil depreciation of \$25 measures both on-site and off-site damages, their net farm income with NRA is equivalent to what we mentioned earlier as a socially and environmentally adjusted net farm income (SENFI). We are proposing to limit natural asset depreciation to on-farm damages; so to the extent, that Faeth et al.'s \$25 includes off-site damages, it understates our environmentally adjusted net farm income (ENFI).

Efficiency Measures

After adjusting the statements to account for the use of natural assets, several new efficiency measures can be calculated which include both simple realignment of traditional measures and new measures to evaluate how well the farm is performing from an environmental perspective.

Adjusting traditional measures can be as simple as calculating the change in the environmentally adjusted net worth (ΔENW) to show how a farmer's wealth has changed over a year after accounting for the use of natural assets:

$$\Delta ENW = ENW_{beg} - ENW_{end}$$

and the environmentally adjusted rates of return to assets (EROA) and to equity (EROE) to show the financial performance from the use of all assets and the farmer's net worth, respectively:

$$EROA = (ENFI + IP - VOLM) / ETA$$

$$EROE = (ENFI - VOLM) / ENW$$

where IP = interest paid by the farm, VOLM = value of unpaid labor and management, ETA = environmentally adjusted total value of assets, and other variables are as defined previously. New measures include two ratios to show the relative difference between the environmentally adjusted and traditional measures of income and of net worth change:

$$ENFI/NFI$$

$$\Delta ENW/\Delta NW$$

If either (or both) of these measures are less than one, the farm has been "living off its capital," that is, using its natural assets. A specific indicator of the change in the natural assets is:

$$\Delta EA$$

where EA is the total value of natural assets included in the balance sheet.

Sustainability can be evaluated in several ways, albeit imperfectly, in these supplemental accounts. The first two are historical tracking of ENW and

ENFI. If these are declining over time, the farm is not sustainable. If they are stable or increasing, the farm can be viewed as sustainable. Another way is the ΔENW and, more specifically, ΔEA, during the period or year being analyzed. If the natural assets are valued to reflect their future ability to produce food and livelihood, then any negative change will indicate a lack of sustainability. The ratios of environmentally adjusted to traditional measures of income (ENFI/NFI) and of net worth changes (ΔENW/ΔNW) can show the unsustainable condition of "living off one's capital." This evaluation of sustainability obviously has to consider the impact of price and yield variation over time. That is, since these are now financial measures, variations and trends may be due to price and yield changes, not physical changes. Hence, as in traditional analysis, part of the evaluation will have to include the use of "normal" prices and yields to take away the variability between years or of unusual circumstances such as drought.

Empirical Issues

Even though the basic conceptual idea of environmental accounting may seem simple, the empirical process of estimating the use of natural assets can seem daunting. However, as Burt (1972) pointed out, the correct conceptual process should drive model development; the available data should not drive the model. As an empirical example we will discuss three methods to estimate and evaluate costs caused by erosive events. We leave the study of changes in the relationships among crop, weeds, pests and other elements of agroecosystems to another paper.

Quantifying the cost of soil depreciation could be a hard matter for farmers on their own. Nevertheless computing depreciation of buildings and machinery is not easier. The most common methods of figuring economic depreciation: the straight line method, the declining balance method and the sum of years' digits are all the result of reasonable compromises. Valuing the soil depreciation needs a compromise too. Since there is no market price attached to the soil losses,[9] we have to establish an indirect method gathering a wide confidence from farmers and economists.

[9]In the words of Hicks, " In order that a thing should have a price, it must be appropriable, but it is not necessary that a thing should be appropriable for it to be a factor of production."

The first method is the market value of the land (net of all transaction costs and contingent taxes). This method is used in normal appraisals of assets. In the case of erosion, changes in value can be obtained if the loss due to erosion is great. If the loss in productive value is gradual, changes would be hard to see on an annual basis and the market value probably would not capture the changes adequately. In such cases, one of the methods discussed next is more appropriate for estimating the cost of natural asset use. We call this the "market valuation" method.

The second method was used by Faeth, et al. (1991) to estimate the cost of erosion by summing up the income losses due to the decrease in physical output calculated using USDA's Erosion-Productivity Impact Calculator (EPIC) model (Williams, et al., 1989) over a 30-year period and under a number of agricultural policy scenarios. We call this the "loss valuation" method.

A third method we propose is to calculate the cost of the soil depreciation as the cost of reconstructing the soil losses. This method considers soil depreciation from a different point of view. Since regenerating the soil is likely to require an environmental friendly rotation which may not fill the financial needs of the short term, we shall have an opportunity cost. Under this approach the accounting does not merely assess the implication of the past behalf on the present income, but also on the future income. According to the underlying assumptions of the Rural Appraisal, while evaluating a generic good we should always keep in mind the purpose of the estimation. Hence if we want to establish a new accounting method for individual farms, we should pay attention to what we have to do to conserve or enhance the value of soils.[10]

To some extent the latter two methods overlap each other, but each has a distinctive goal. The "loss valuation" method will fit the needs of economists and politicians. The "reconstruction" method could be preferred by farmers, for instance, when choosing their long run planning. They can understand how they are depleting their land, because the opportunity cost to regenerate the soil degradation will increase year by year.

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[10]Pearce and Turner (1990), in their analysis of sustainable development, paid attention to the meaning and desirability of maintaining the "natural capital stock" as a condition for sustainable development. In a more specific sense, Hueting (1986) states: "Degradation [of soil] means reduction in the content of organic matter in the top soil and soil compaction. The following sustainability standard can be formulated: the content of organic matter in soil has to remain at such a level that agriculture is possible without requiring soil structure improvement through additives."

Technically the "reconstruction" method needs the same analytical instrument as the "loss valuation" method, (i.e., EPIC and FAPRI), but it is more closely related to the solution of the problem. The "reconstruction" method aims to establish what a farmer needs to do to solve the degradation problem; that is, if we deplete or degrade a natural asset, we should reconstruct it for future generations.

As a direct consequent of the underlying assumption of the reconstruction method we can state that:

- the "income losses" suffered when converting a farm towards sustainable agriculture should be considered an investment, so that it must be considered a cash loss instead of a cost. As long as we are improving the soil we should consider that we are capitalizing that cash loss[11]. The start up money needed for this reconstruction investment is:

  $\Sigma(Y_0-Y_t)/(1+i)^t$, for t=1 ... n

  where Y_0 is initial yield

  Y_t is yield at year t

  i is real interest rate, and

  n is the period under consideration

- moreover the second method places emphasis on the value of the soil in itself, unlike the first method which places emphasis on the value of the flow of services attainable from the soil.

The first step in the "reconstruction" method is to compute the soil degradation in physical terms. There are a number of models which could be used in evaluating the physical change of soil. To identify a single model, we mention EPIC since it is being used by a large number of scientists. The second step is to find an environmental friendly rotation to regenerate the soil degradation. The third step is the evaluation of the opportunity cost of that rotation. As outlined above, we can use EPIC again to simulate an environmental friendly rotation to reconstruct the soil functions. Running EPIC and any other model requires a great deal of experience, hence an interdisciplinary team is most likely needed. While the Faeth et al.'s method estimated various crop rotations for 30 years with soil erosion and with normal weather year repeated,

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[11] To calculate the cash losses we should consider the Natural resource Accounting

the reconstruction method is likely to require an estimation over a shorter period. That could make the simulation of the future price series easier.

CONCLUDING REMARKS

In this paper, we have proposed a method of adjusting the traditional accounting system for farms. This adjustment will allow a farmer to continue to track the traditional measures of profit and solvency as well as to evaluate the contribution of and the impact on the farm's natural assets. The environmentally adjusted net farm income (ENFI) and net worth (ENW) show the true income and wealth due to production. By using these measures in future analysis, farmers can see the entire impact of their activities and make better decisions in regard to sustainable development. Three methods of valuing losses due to erosion were discussed. This can be regarded as an initial step to bringing some ecological issues into the economic framework of farm management. It is in its very early stage, but we believe there is enough evidence that more work on it is needed.

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