

Natural Resource Accounting Systems and Environmental Policy Modeling

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Abstract

Natural Resource Accounting combines national income and product accounting concepts with analysis of natural resource and environmental issues. This paper considers this approach for the RCA Appraisal required by the Soil and Water Resources Conservation Act. Recent natural resource accounting literature is examined in light of requirements of the RCA Appraisal. The paper provides a critique of the economic content of the Second RCA Appraisal and develops a natural resource accounting framework for considering these same effects. Finally, the paper summarizes the benefits which might result from adopting a more explicit Natural Resource Accounting framework for the next RCA Appraisal.

Natural Resource Accounting Systems and Environmental Policy Modeling

"A country could exhaust its mineral resources, cut down its forests, erode its soils, pollute its aquifers, and hunt its wildlife and fisheries to extinction, but measured income would not be affected as these assets disappeared." Repetto, et al. (1989, p. 2)

Introduction

The phrase "Natural Resource Accounting Systems" is rapidly reaching buzz-word status in some circles of the environmental policy analysis community. The idea implicit in the phrase is to combine national income and product accounting (NIPA) concepts with the analysis of natural resource and environmental issues in one of two ways. The first would apply NIPA concepts or methods to the analysis of public policy questions involving non-market environmental goods or exhaustible natural resources. The second would include magnitudes related to these aspects of economic activity in national income aggregates. Of course, the two approaches are not alternatives. They should be regarded as mutually reinforcing analytical strategies.

It is useful to distinguish between these related approaches because they have different objectives: the application of NIPA concepts to environmental and natural resource policy analysis aims to improve the consistency and organization of data and results reported in the analysis of these issues. This analysis is largely *ex ante* policy analysis and is usually prescriptive in nature. This objective of natural resource accounting will be referred to as the *ex ante* or prescriptive objective. On the other hand, inclusion of welfare or income measures related to non-market environmental and natural resource issues in NIPA aggregates aims to raise the prominence of these aspects of

economic activity in national policy debate and to correct deficiencies of NIPA as a measure of economic well-being. Analysis for this objective is generally historical, and will be termed the ex post or evaluative objective of natural resource accounting.

This paper follows these two threads through the recent literature of natural resource accounting and assesses the idea in the context of a periodic natural resource appraisal conducted by the U. S. Department of Agriculture (USDA). First, the appraisal requirement of the Soil and Water Resources Conservation Act of 1977 (RCA) is interpreted as statutory direction to the Secretary of Agriculture for periodic data collection, analysis and reporting that amounts to natural resource accounting for the agriculture sector. Next, insights of recent literature of natural resource accounting are examined in light of the RCA Appraisal requirement.

The paper proceeds to a critique of the economic content of the Second RCA Appraisal. The various effects considered in the most recent RCA Appraisal are discussed and recast in a natural resource accounting framework. The principles of natural resource accounting that apply to U.S. Agriculture are discussed in this framework. Finally, the paper summarizes the benefits which might result from adoption of a more explicit natural resource accounting framework to organize efforts for the next RCA Appraisal.

The Soil and Water Resources Conservation Act of 1977

The RCA clearly calls for both ex ante or prescriptive analysis and ex post or evaluative analysis. A few references to the Act suffice to support this assertion. First, the Act's "findings" convey the scope of effects encompassed.

Sec. 2. The Congress finds that:

- (1) There is a growing demand on the soil, water, and related resources of the Nation to meet present and future needs.

(2) The Congress, in its concern for sustained use of the resource base, created the Soil Conservation Service of the United States Department of Agriculture which possesses information, technical expertise, and a delivery system for providing assistance to land users with respect to conservation and use of soils; plants; woodlands; watershed protection and flood prevention; the conservation, development, utilization, and disposal of water; animal husbandry; fish and wildlife management; recreation; community development; and related resource uses.

(3) Resource appraisal is basic to effective soil and water conservation. Since individual and governmental decisions concerning soil and water resources often transcend administrative boundaries and affect other programs and decisions, a coordinated appraisal and program framework are essential.

Note from paragraph (2) that the Act extends far beyond commercial agriculture to "fish and wildlife management; recreation; ... and related resource uses". In the present context, the phrase "related resource uses" does little to constrain the scope of the Act. The Second RCA Appraisal followed a comprehensive approach consistent with this language. Paragraph (3) refers directly to the resource appraisal, and suggests that to be effective, a natural resource appraisal must encompass multi-jurisdictional considerations as well as interactions among multiple programs and policy decisions. A results-oriented, ex post evaluation of outcomes is at least a reasonable way of accomplishing this goal.

Section (5) directs the Secretary to conduct "a continuing appraisal of the soil, water, and related resources of the nation". Among other specific charges, the appraisal is to include the "current status" of "quality and quantity" of resources pertinent to the uses mentioned above, as well as "changes that have occurred in the status of these resources". This assessment of "current status" conforms to the ex post objective of natural resource accounting. With all policies taken together, all unanticipated effects included, all stochastic events realized, what was the actual interaction

between agriculture and the natural environment, and what is the resulting state of natural resources? The conduct of this analysis in monetary units (as opposed to merely gathering physical data on natural resource status) is required by Section (7) of the Act which calls for an annual report, based on the Appraisal, "to assess the balance between economic factors and environmental quality factors". In sum, the Act requires a periodic appraisal of interactions between agricultural activity and natural resources, broadly defined; the assessment of magnitudes of "stock" resources at various points in time, as well as the "flows" indicated by the changes in those stocks; and a comparison between effects captured by narrowly defined "economic" or market activity and non-market "environmental quality factors", with the comparison implying reduction to a common unit of measurement. Fulfillment of these tasks amounts to accomplishing the ex post evaluation objective of natural resource accounting, and an efficient way to organize the project would be to more formally adopt a framework capable of integration with NIPA.

It is also clear from the Act that the Appraisal should support ex ante, prescriptive analysis. Section (6) calls for preparation of a "soil and water conservation program". In particular, "the program shall set forth direction for future soil and water conservation efforts of the United States Department of Agriculture based on the current soil, water, and related resource appraisal developed in accordance with section 5 of this Act, taking into consideration both the long- and short-term needs of the Nation, ...". Thus, ex ante policy analysis of the soil and water conservation program is to be based on the framework constructed for the periodic RCA Appraisal. In several places the Act calls on the appraisal framework to provide "costs and benefits" and to consider "alternatives" in broadly conceived prescriptive analysis, including "recommendations for new legislation where warranted".

If natural resource accounting can deliver the capability to do both the ex post evaluative analysis called for in the Act's requirements for the Appraisal, and the ex ante prescriptive analysis which the Appraisal framework must support, it would seem to be an appropriate tool for the USDA to use in organizing efforts to comply with the Resources Conservation Act.

Natural Resource Accounting

While the notion of natural resource accounting is reaching a currency it has not enjoyed before, the idea has a long history. Both the ex ante and the ex post objective of natural resource accounting can be regarded as extension of existing NIPA procedures, and as such, the proposal follows in a fairly well traveled path. The most widely known attempt to improve on GNP as a measure of welfare was undertaken by Nordhaus and Tobin (1973). Their aggregate "measure of economic welfare" sought to extend and remove anomalies from the officially reported NIPA aggregates in several areas, but environmental and natural resource issues were not prominent among them. Peskin (1976) offered a framework to extend NIPA to include "environmental assets", apparently with a view to serving both objectives. Mancur Olson (1977) also examined deficiencies of existing NIPA aggregates for natural resource and environmental issues and proposed consideration of changes.¹

Figure 1 shows the symmetry between environmental assets and human capital assets in the context of an extended circular flow diagram. Positive or negative changes in the value of environmental or human capital assets during a period are analogous to investment or depreciation in conventional assets. Many proposed extensions to NIPA involve estimation of changes in the value of human capital²; natural resource accounting proposes imputations for changes in environmental assets. In addition to changes in values of assets, natural resource accounting and other extensions may incorporate estimates for current flows between sectors which do not pass through markets.³

The recent growth of interest in natural resource accounting has been driven by the need for better ex post evaluation of growth in developing countries. For a developing country which relies heavily on natural resource-based industries, conventional NIPA procedures are woefully inadequate, ignoring potentially crucial changes in asset position. Both the substance of the inadequacy of conventional accounts and the sources of the current interest in natural resource

accounting are reviewed by Repetto, et al., 1989 and Ahmad, et al. 1989. While similar considerations are also important for industrial countries, a greater emphasis is likely to be placed on accounting for externalities more remote from market activity. For instance, the Second RCA Appraisal found that about a third of the annual damages from off-site erosion and runoff were damages to recreation opportunities. Incorporation of such effects raises accounting issues which do not arise in accounting for natural resource asset inputs to market oriented productive activity.

Regarding a move to natural resource accounting as a revision of NIPA procedures, the first question that arises is whether the revision is desirable. Although the shortcomings of the conventional NIPA aggregates are well known, suggestion of departures from conventional procedures meet with resistance. There are a variety of practical reasons for this resistance. Maintaining consistency in existing time series, maintaining "integrity" in existing accounts derived largely from market transactions which avoid conceptual and statistical vagaries of non-market estimation, and other practical reasons, all counsel caution in departures from convention. All of these objections are satisfied by a scheme of refining estimation of non-market quantities consistent with the needs of NIPA but not including such estimates in reported aggregates until a sufficient consensus develops around the conceptual and statistical basis for the new estimates. This approach has been taken with recently added imputations such as the rental value of owner occupied housing.⁴

If the decision is to extend NIPA (or some sector of NIPA), the analysis immediately faces the question of just how far to go. Which non-market phenomena should be measured as dollar amounts, and which should be included in NIPA aggregates? This question is answered by existing systems of accounts and must be addressed by proposed extensions. The U.S. Bureau of Economic Analysis incorporates very few goods for which there is no market transaction. Farm products consumed on farms is an example. The United Nations' System of National Accounts (SNA) is more comprehensive, especially for changes in the value of natural resource assets, but these changes are excluded from aggregate flow accounts by reconciliation procedures.⁵ The

It is immediately apparent that the organization of the report was not designed to facilitate economic analysis. The only top level distinction among effects which seems to have direct economic content is between on-site and off-site effects of soil erosion. On the other hand, effects which suggest similar economic analyses are separated by the organizing principles applied. Thus, competition between urban sprawl and cropland would appear to be similar, in economic terms, to competition between irrigation and non-agricultural uses of water; or wetland preservation might have been treated as a land use issue, offering an alternative to the use of land for crop production. Also, there is a relatively small fraction of effects for which a dollar measure was attempted. The one area where economic measurement is fairly rich is sediment impacts of water-based erosion and flood damage. In this area, the report contains four different sets of estimates which seem largely independent and overlap in varying degrees⁹. Some of the estimates indicated in Table 1 are fragmentary: estimates of the value of wildlife habitat on rangeland are only for the Rio Grande Plains and the Edwards Plateau in Texas. The Appraisal's estimate of wind erosion damage is only for New Mexico. The issue of consistency among estimates does not often arise in the appraisal, likely because there is little attempt to aggregate or compare the various estimates. When an attempt is made to compare on-site and off-site damages from soil erosion,¹⁰ the report notes that the estimates are "not entirely comparable".

The Act calls for a comprehensive appraisal of the current status of natural resources related to agriculture, either as inputs or as media for agricultural externalities, positive or negative. The Act also calls on the appraisal to provide a framework for ex ante analyses of the costs and benefits, market and non-market, of policies. Although the 1985 Appraisal encompassed a very broad range of effects, there was no apparent organizing framework which would provide for consistency across estimates, support a claim of comprehensiveness of the appraisal, or support the ex ante analysis clearly anticipated by the Act. The Second appraisal was an ambitious analysis of agricultural natural resource issues, requiring the dedicated effort of many people over an extended

criterion applied in the SNA is "closeness" to the market. Eisner (1988) proposes a potentially important criterion in the distinction between measurement of "welfare" and measurement of "economic activity related to welfare". The latter, of course, is a much more plausible goal.

Another criterion important in extensions of NIPA to incorporate natural resource and environmental services is whether the effects are potentially subject to alteration by policy.⁶ Thus, the services of the atmosphere in providing oxygen for combustion are clearly valuable, but do not appear to be subject to manipulation by policy. On the other hand, the services of the atmosphere in providing the accustomed geographic and temporal patterns of weather, may be subject to alteration by economic activity, and therefore by public policy.

We should expect the boundary of economic activity encompassed by NIPA to change over time as the nature of the economy changes, and as estimation capabilities change. The definition of economic activity related to welfare should be ambitious in concept, but it should be recognized that estimation capabilities will never keep pace with desires. Recently developed estimates will probably be kept in satellite accounts, as presently contemplated natural resource revisions of the SNA⁷, or similarly quarantined, until conceptual and empirical consensus⁸ is strong enough to justify inclusion in official aggregates.

The Second RCA Appraisal

Table 1 lists, in outline form, the economic effects touched on by the Second RCA Appraisal. The outline generally follows the presentation of the Report. The presence of a dollar estimate associated with an effect is indicated by a page reference to the Report, appearing in the right hand column of Table 1. Some of these dollar estimates are not central to the analysis of the Report; indeed, the economic effects of Table 1 impose a structure on the Report which was not a part of the appraisal's analysis.

period. To note that the effort was not organized around an economic framework and to propose such a framework for the next appraisal in no way detracts from our commendation of the effort.

Natural Resource Accounting for the Next RCA Appraisal

The framework developed below follows loosely the work of Peskin (1976, 1989a, 1989b). The application is for U.S. Agriculture, and hence is more specific in focus than Peskin's work. The present analysis does not describe consolidation procedures by which the various industry sectors could be combined to produce aggregates such as net national product (NNP) and modified NNP, although capability for consolidation is clearly intended. The present treatment concentrates on the agriculture sector and, unlike Peskin, does not account for a nature or household sector, but is generally consistent with such sector accounting. In a comprehensive accounting system, a household sector is both a consumer and a producer of a variety of natural resource-related effects. If included, a nature sector is seen as an intermediary in many external effects. Thus, a change in expected flood damage in a non-agricultural sector which results from a change in agricultural practices is shown as an effect of the agriculture sector on nature, and an effect of nature on the other sector. Nature could also be regarded as a source of effects (for example, a source of sediment) but many such effects would be ruled out by the criterion of susceptibility to alteration by public policy.

Following Olson (1977), and Peskin's Option 1 (1989b, p. 76), the present framework views non-market effects with impacts on business rather than households as additions or subtractions to profits and therefore as included in the conventional accounts. To be sure, if these unpriced effects are unintended consequences of other economic activity they are valued and appear as line items in the present framework, but since their effects are already captured by reductions or increases in value added, they do not appear in the aggregates contemplated by the present framework. If the unpriced effect is a flow of environmental asset services - a "non-marketed, but valuable, factor input" (Peskin 1989a p. 17) - the value to the firm of the free use of the input is a part of the firm's

profit, and is captured by the conventional accounts. We need not disentangle such effects until the service flow is potentially affected by policy, and then only to the extent that value added would be affected by the policy. Thus, for ex post purposes, the conventional accounts capture such effects. For ex ante purposes, it is not usually necessary to value the entire contribution of the unpriced effect, but rather it is only necessary to determine the change in value added implied by the impact of the policy under analysis on the environmental service flow in question.

Table 2 shows 1985 farm sector output and income as presented in Table 1.21 of the July 1988 Survey of Current Business, with additions to extend the accounts to incorporate effects treated in the Second RCA Appraisal. Tables 3 and 4 are example worksheets supporting the additional entries in Table 2. The important distinctions necessary to accomplish the extension are:

- the distinction between effects on assets and effects on current flows;

- the distinction of effects which enter the cost functions of businesses from effects which impinge directly on household welfare; and

- the two way classification of non-market effects according to sector of origin (agriculture or other) and sector of impact.

Each of these distinctions is discussed in turn.

Assets and Current Flows

The first organizing principle is the distinction between current flows and changes in the value of assets. In Table 2, all changes in the value of assets are included in natural resource depreciation entries. All other new entries arise from current flows.

Gross investment is a part of current production and enters into gross national (or sectoral) product. The change in the value of assets is subtracted to form net product. The creation of an

asset initiates two flows: the flow of depreciation (or allowance for capital consumption), and the flow of services which the asset provides. Depreciation is entered explicitly in NIPA, and the flow of services is an element of value added, not distinguished as a separate line item. Analogous treatment is proposed for natural resource assets, but differences in treatment are indicated by the special nature of some natural resource assets.

A natural resource asset is any natural material or process which has the potential to generate a continuing influence on economic activity, with the value of the influence potentially subject to alteration by human activity. The continuing influence can be positive, like a ground water aquifer, or largely negative like the natural process that generates floods. Both examples have the potential to exercise their influence over many years, and both are subject to alteration by human activity. The Second RCA Appraisal catalogs a variety of ways in which each flow of influence can be altered, favorably or otherwise, by human activity.

The value of a natural resource asset will be taken to be the expected net present value of the flow of services or influences to be generated by the asset. For the accounting structure set out in Table 2, the value of the asset is only interesting as an intermediate step in calculating the change in the value of the asset from one period to the next. That change is natural resource depreciation. Clearly, natural resource depreciation could be positive or negative. There are a variety of questions which must be addressed in any measurement of natural resource depreciation, and are beyond the scope of this paper¹¹. Further, no analysis is offered of the issue of using price times quantity as a measure of an effect, which is consistent with NIPA, or using a compensation or consumer surplus measure, which is consistent with the well developed literature of cost benefit analysis.

In any case, conventions must be adopted concerning unknown future events which will affect the present value of the asset. In order to calculate the expected present value of a stream of future influences, assumptions are required about all factors which will affect the value of the influences

in future periods. If there is reason to change the assumption about future considerations which bear on the effect being measured, the altered stream of future effects will change the calculated present value of the asset. Conventions must be adopted for changing the assumed stream of future values of factors which affect the asset services being valued. It might be assumed that factors remain at current levels, grow or decline at recently established exponential rates, maintain an optimal level which can be inferred from some present magnitude, or are based on a new projection of all important variables for each period, using the best information available at that time. In any case, it is crucial that all estimates at a single period incorporate consistent assumptions about future values.

Households and Firms

A natural resource asset can be owned by individuals or firms in the economy. Agricultural productivity of soil is an example. It differs from "reproducible" assets only in that it was not originally created by investment activity. Inclusion of such an asset in NIPA is a straightforward extension. The period by period change in the value of the asset is estimated and entered as a capital consumption item, and the flow of services enters into cost functions of the owners of the asset and is included in NIPA as part of value added. Some natural resource assets generate service flows which fall on households rather than businesses and are not captured by NIPA; in addition to estimation of the period by period change in the value of such an asset, we must estimate the value of the flow of services and include that value in extended accounts. For example, a sport fishery, like any other natural resource asset, may be subject to depreciation or appreciation. A sport fishery is different in the sense that the flow of services from such an asset are not captured in the conventional accounts. This issue also arises in the case of current non-market flows not associated with assets, and is discussed below.

The change in the value of an asset is shown in the natural resource depreciation entry, changing net farm product, but not entering into gross farm product. The current flows from natural resource assets, as well as any other current non-market flows, are captured in entries before the calculation of gross farm product. The first of these entries to be discussed records current non-market effects created by agriculture: line 9 of Table 2. A summary of the sources of this entry is provided in Table 3.

Current non-market effects are divided into effects on households and effects on business. This division is needed because non-market effects on households have not entered the NIPA accounts in any other way and must be treated differently than effects on business. Effects on business alter cost functions and ultimately have an effect on value added, which is already treated in the accounts. For example, upstream irrigation can cause salinization of downstream irrigation water, resulting in lower yields and higher cost in the current period. This effect causes lower farm receipts from crop sales and perhaps higher purchases of intermediate goods and services, both of which reduce farm product. Even though non-market effects on firms are incorporated elsewhere in the accounts, they are estimated here because such effects are important for ex ante analysis of policy alternatives. These effects are classic instances of market failure and are a likely area for government intervention. Distinguishing the magnitudes of the effects is a first step in analysis of such policies.

Sector of Origin and Impact

The extent to which the agriculture sector exchanges current non-market effects with other sectors, and the balance of harm or benefit of these exchanges may be of interest; further, adjusted sector accounting should also keep track of intersectoral impacts on natural resource assets. Effects with impacts on business are "netted" out of the aggregate farm product estimate by means of the net value of non-market effects on business entry, discussed below. The entry for non-market effects

from other sectors, line 20 on Table 2, accounts for externalities generated by other sectors with impacts on agriculture. Examples are ozone damages to crops and flooding damage to agriculture from construction sector sediments. Like other current effects, this entry could record current flows from natural resource assets or simply current externalities. Essentially all effects considered in the Second RCA Appraisal are best regarded as flows generated by natural resource assets or changes in the values of those assets, but the accounting structure proposed in Table 2 would also account for non-market effects which are not associated with a natural resource asset.

The net value of non-market effects on business entry, line 5 of Table 2, is a device to avoid double counting in the case of non-market effects which fall on business. Such effects are incorporated in the conventional accounts as part of the residual value added of enterprises, but it is desirable to account separately for these items since they have implications for public policy. In order to show these effects as separate line items it is necessary to include a balancing entry of equal magnitude and opposite sign. Thus, the net value of non-market effects on business entry is the sum of current non-market effects on business created by agriculture, line 11, and non-market effects from other sectors, line 20. Non-market effects on households do not currently enter the accounts, so extension of the accounts to include such effects alters farm product.

Illustration of Treatment of Global Climate Change

Before concluding, it is useful to consider the various ways in which a specific effect enters into the extended accounts for the next RCA Appraisal. Global climate change is an effect which did not appear in the 1985 Appraisal but may appear in the next Appraisal. Climate change alters the productivity of agriculture, an effect which is best regarded as acting through a natural resource asset. In this case, the climate is regarded as an asset which generates a stream of future services. The value of the asset is the present value of the stream of services. If economic activity in a given period can be predicted to alter the expected stream of climate services, a change in the value of the

"climate asset" is implied. This change enters into natural resource depreciation which contributes to the aggregation of Table 2 in line 23. The value of a change in climate on agricultural production could be estimated from simulation of productivity under different climate regimes or from hedonic regression of prices of agricultural land on climate variables, holding constant other relevant influences on productivity. Aggregate depreciation of the climate asset is the aggregate decrease in the value of agricultural land which can be attributed to productivity impacts of climate change occurring during the period. There is always the possibility that the change would amount to appreciation rather than depreciation. In addition to the asset effect of the current period's activity, the climate asset generates a current flow of services. This effect falls on business rather than households, and is therefore included in the value added of conventional accounts. It may be desirable to ask what impact climate change had on the previous period's farm product. If so, the number enters into Table 2 lines 20 and 12, in proportions depending on the agriculture sector's relative contribution to production of the period's altered climate . A balancing entry would be required in line 5 to avoid double counting.

The framework could also be called on to support ex ante analysis of agricultural policies intended, at least in part, to "invest in the climate" by extracting carbon dioxide from the atmosphere and warehousing it as biomass, for example, by planting trees on conservation reserve program (CRP) lands. Analysis of such a policy would require aggregation across sectors, which goes beyond the rudimentary illustrative character of Table 2, but it should be clear that a comprehensive framework would be needed. Generally, such an "investment" could be expected to take the form of a reduction in value added in agriculture, perhaps compensated by subsidies to operators, and a positive increment in the value of the climate asset, entered in the natural resource depreciation entry. For such a policy, the analysis would project outcomes, summarized in national account format, with and without the proposed policy. The adequacy of such comparisons, and the role of natural resource accounting in contributing to improvements, is discussed below.

Conclusion

The RCA calls for ex post evaluation of the aggregate impacts of policies as well as data collection for ex ante analysis of new policy interventions. Both of these functions may be served by application of natural resource accounting principles to guide the data collection and analysis effort that will be undertaken for the next RCA Appraisal. Use of these organizing principles can help in several ways. First, starting from an aggregate sector viewpoint (Table 2) and working through supporting worksheets (Tables 3 and 4) is a hierarchical procedure which imposes consistent conceptual foundations on all underlying estimates. This hierarchical organization of estimation efforts could lead to improved consistency in geographical and temporal units of analysis, a common definition of the agriculture sector production boundary, and commonly accepted conventions for the host of assumptions which underlie the necessary estimates.

Where estimates are available, their organization into this aggregation hierarchy would facilitate subsequent analysis; where estimates are not available, or where the variance about existing estimates is large, the present framework identifies areas lacking quantification. These areas are weak links in the chain of reasoning which must support monitoring and policy analysis. In facilitating comparison of the state of knowledge in different areas, the comprehensive framework would aid in setting research priorities.

In the early stages of development of a system of natural resource accounts it should be expected that confidence in estimates of physical indicators will precede consensus regarding dollar valuation of the effects represented by these indicators. As they are developed, such physical indicators can serve as interim guides for both ex post and ex ante analysis. Whether based on physical indicators or dollar valuations, either form of analysis should rely on "baseline" or status quo time series which can serve as points of departure from which changes can be evaluated. Further, a natural resource baseline would point out tendencies or projected trends which suggest problems or issues to which public policy could be addressed. The functional roles and

relationships among these indicators, baselines, and implied issues are organized into a coherent analytical whole under the natural resource accounting framework.

To the extent that dollar valuation is accomplished and natural resource accounting aggregates are fair approximations of welfare, ex post analysis is done by estimating the quantities in the accounts, pointing out changes from one appraisal to the next, and analyzing the various factors' contributions to the change. If the extended accounts are an adequate approximation to the welfare effect of agricultural activity, ex ante policy analysis is done by comparing values of the aggregates projected to occur with and without the policy under analysis. If the aggregates of natural resource accounting are not regarded as adequate approximations of welfare for ex ante analysis, the data developed for natural resource accounts would also be useful for construction of an improved measure of welfare in the tradition of cost-benefit analysis. In either case, the natural resource accounting framework could provide the RCA Appraisal effort with organization around economic evaluation principles, consistency of assumptions, and a check on comprehensiveness; such a contribution should be regarded as a welcome improvement.

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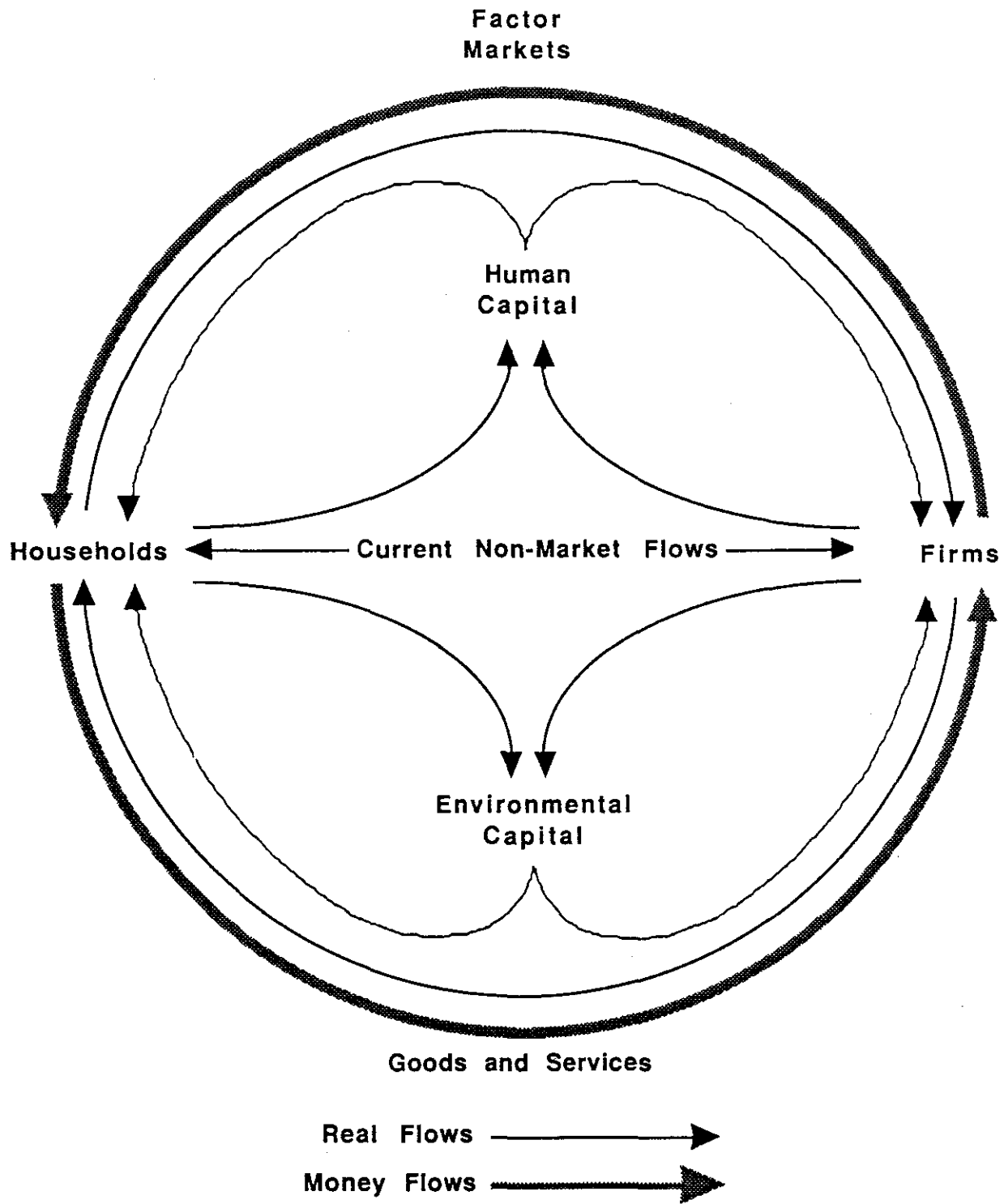


Figure 1. Extended Circular Flow

Table 1
Natural Resource and Environmental Effects Encompassed by the Second RCA Appraisal

Land Use		Sediment	117, 118
Urban sprawl		In-stream effects	
New cropland		Recreation	
On-site Effects of Erosion		Water storage	
Sheet and rill and wind		Transportation	
Short term crop damage	25	Other in-stream damage	
Long term productivity effects		Off-stream effects	
Ephemeral gully and gully		Flood damage	
Salinization		Agriculture	
Degradation of Rangeland (overlaps on-site erosion)		Damage to cropland	
Erosion		Damage to growing crops	
Deterioration of Plant Communities		Other flood damage	
Damage to forage		Water conveyance	
Damage to wildlife habitat	66	Water treatment	
Damage to water quality and quantity		Other off-stream effects	
Damage to recreation potential		Salinity	
Availability of irrigation water		Irrigated crop yields	
Irrigation quantity and technology		Livestock Health	
Infiltration on agricultural land		Human health	
Artificial recharge		Cleaning effects	
Competing uses		Plumbing and water treatment effects	
Domestic and Industrial use		Aquatic habitat	
In-stream flows		Wind erosion	120
Flood Damage		Short term crop damage	
Agriculture as a victim of flood damage	89-91	Long term productivity damage	
Agriculture role in causing/controlling flood damage		Human and livestock health	
Flood damage to other industrial sectors		Visibility	
Ozone and Acid Deposition		Soiling	
Effects on crops	96, 98	Pollution of ground water	
Effects on forests		Wildlife habitat	
Effects on surface water	98	Wetland preservation	
Effects on soil	98	Effects on groundwater quantity and quality	
Off-site effects of erosion and runoff		Erosion of shorelines	
Effects on surface Water Quality		Climate modification	
Pesticides		Storage of floodwaters	
Nutrients		Trapping of sediments	
Animal Wastes			

Table 2

Natural Resource Accounting Framework for RCA Appraisal

[Billions of dollars]

1	Farm output	—
2	Cash receipts from farm marketings	144.9
3	crops	75.1
4	livestock	69.8
5	Net value of non-market effects on business	—
6	Gross rental value of farm housing	10.9
7	Farm products consumed on farms	.9
8	Other farm income	5.4
9	Current non-market effects created by agriculture	—
10	Effects on households	—
11	Effects on business	—
12	Agriculture	—
13	Other	—
14	Changes in farm inventories	-3.3
15	crops	-1.4
16	livestock	-1.9
17	Less: Intermediate goods and services purchased	83.4
18	Intermediate goods and services other than rent	72.8
19	Rent paid to non-operator landlords	10.6
20	Plus: Non market effects from other sectors	—
21	Equals: Gross farm product	—
22	Less: Capital consumption allowances	22
23	Less: Natural Resource Depreciation	—
24	Depreciation of agricultural natural assets	—
25	Agricultural causes	—
26	Non-agricultural causes	—
27	Depreciation of non-agriculture natural assets caused by agricultural activity	—
28	Equals: Net Farm Product	—
29	Less: Indirect business taxes	3.1
30	Plus: Subsidies to operators	6.3
31	Equals: Farm national income	—
32	Compensation of employees	9.5
33	Proprietors' income and corporate profits with inventory and capital consumption adjustments, including natural resource depreciation	—
34	Net interest	15.3
35	Current non-market effects on households	—

Table 3

Current Non-Market Effects Created by Agriculture

1	Effects on Households	—
2	Non market recreation benefits	—
3	Rangeland	—
4	Other	—
5	Surface water quality	—
6	sediment damage to recreation	—
7	flood damage from agricultural sediment	—
8	current salinity damage to households	—
9	Wind erosion damages	—
10	health	—
11	visibility	—
12	soiling	—
13	Ground water pollution	—
14	Effects on Business	—
15	Agriculture	—
16	sediment damage to water conveyance	—
17	salinization of agricultural water	—
18	current flood damage from agricultural sediment	—
19	Other sectors	—
20	Sediment damage to water storage	—
21	Sediment damage to transportation	—
22	sediment damage to water conveyance	—
23	Flood damage from agricultural sediment	—
24	Water treatment	—
25	Costs of salinization caused by agriculture	—
26	Damages from wind erosion	—

Table 4
Natural Resource Depreciation

1	Change in agricultural natural assets due to agricultural activity	---	30	Long-term damage from ozone and acid deposition	---
2	Change in agricultural productivity of soils	---	31	Perennial crops	---
3	Due to physical deterioration	---	32	Forests	---
4	Due to changes in practices applied	---	33	Surface water	---
5	Due to changes in available technology	---	34	Soils	---
6	Due to changes in demands for ag. products	---	35	Change in non-agricultural natural assets due to agricultural activity	---
7	Change in agricultural productivity of rangeland	---	36	Soil erosion and runoff	---
8	Change in agricultural productivity due to change in availability of irrigation water	---	37	Recreation	---
9	surface water	---	38	Water storage	---
10	groundwater	---	39	Transportation	---
11	Change in agricultural productivity due to off-site agricultural erosion and runoff	---	40	Flood damage	---
12	Damage to agricultural water storage	---	41	Water conveyance	---
13	Flood damage	---	42	Water Treatment	---
14	Damage to water conveyance	---	43	Salinity	---
15	Salinity	---	44	Damage from wind erosion	---
16	Damage from wind erosion	---	45	Human health	---
17	Other	---	46	Visibility	---
18		---	47	Soiling	---
		---	48	Other wind erosion damage	---
19	Change in agricultural natural assets due to other activity	---	49	Other off-site natural asset effects of agricultural activity	---
20	Agricultural Water storage	---	50	Wildlife habitat	---
21	Flood damage	---	51	Damage to water quality and quantity	---
22	Cropland	---	52	Damage to recreation potential	---
23	Other flood damage to agriculture	---	53	Damage from current pollution of groundwater	---
24	Agricultural water conveyance	---	54	Other	---
25	Salinity effects on agricultural uses of water	---			
26	Damage from wind erosion	---	55	Natural resource depreciation	---
27	Cropland	---			
28	Growing crops	---			
29	livestock health	---			

Endnotes

1. Natural resource accounting is by no means the only area proposed for extending NIPA or revising the construction of aggregates. Eisner (1988) surveys proposed NIPA extensions and remarks that "the value of nonmarket household product, if it were purchased in the market, would be huge"; and, an imputation for the value of leisure is "enormous", "dwarfing" all other imputations.
2. See Eisner (1988 and 1989).
3. To date, the most comprehensive extension of national income and product accounts to include environmental assets is the World Resources Institute study of petroleum, forestry and soil assets in Indonesia (Repetto, et al., 1989). The estimated correction to officially reported Indonesian GDP for the year 1984 (the last year of the study) amounted to a 17 percent reduction. Over the 13 years covered by the study, the correction for changes in natural resource asset values turned growth into decline five times. By far the largest corrections were for petroleum resources. While there are no comprehensive U.S. estimates available, the Second RCA Appraisal reported water erosion and runoff damages from agricultural land that alone amounted to 3.2 to 13 billion dollars, or 6 to 24 percent of 1985 net farm product.
4. See Survey of Current Business, July 1988, Table 8.9 for a list of current imputations, and Carson (1987) for an overview of data and methods for these estimations.
5. See Bartelmus (1989).
6. See also Peskin's analysis of such effects and the distinction of "marginal" and "total" measures (Peskin 1989b, p.67).
7. Lutz, et al. (1989).
8. Norgaard (1989).

9. USDA (1989, p. 87 et seq. and 101 et seq.).

10. USDA (1989, p. 9).

11. The topic is well researched (see the references cited in Repetto, et al., 1989) if not completely settled (for example, Hartwick, 1989).