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Integrating natural capital into system of national accounts for policy analysis: An application of a computable general equilibrium model☆

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ABSTRACT

Natural capital is an asset that provides natural resource inputs and environmental services for economic production. Regional patterns of production and consumption have direct and indirect effects on sustainability of its natural capital. Traditional gross domestic product (GDP) estimates fail to explicitly and fully account for natural capital in system of national accounts (SNA). To address this gap, this study builds on United Nation's System of Environmental-Economic Accounting (SEEA) and provides a methodological framework to integrate natural capital into system of national accounts, in input-output table. It further illustrates how natural capital-integrated system of national accounts in input-output table can be used as an effective tool for natural resource management and policy analysis in computable general equilibrium (CGE) modeling framework. Results indicate that, without natural capital accounting and integration into system of national accounts, GDP estimates may give misleading signals as a measure of a region's economic performance, where economic growth could be at the expense of natural capital depletion.

1. Introduction

Natural capital is the sum of all natural resource stocks that provide beneficial flows of goods and services, and includes resource stocks that are potentially renewable, such as forests, as well as non-renewable stocks such as oil and minerals (Daily, 1997; Repetto et al., 1989). Natural capital is an asset that provides natural resource inputs and environmental services for economic production. Natural capital is generally considered to comprise three principal categories: natural resource stocks, land and ecosystems (UN et al., 2003). Most nations rely on natural capital for their economic growth measured as gross domestic product (GDP). Therefore a nation's patterns of production and consumption have direct and indirect effects on the sustainability of its natural capital.

The system of national accounts (SNA) is the internationally agreed standard set of recommendations on how to compile measures of economic activity in accordance with strict accounting conventions based on economic principles (UN et al., 2009). SNA estimates GDP from final demands or value-added, focuses primarily on producers' and consumers' economic activities from monetary markets perspective only.[2] Therefore, in the production process, GDP fails to directly and fully account for depletion of natural capital stocks (such as forests), environmental degradation (such as pollution and loss of soil productivity), and ecosystem services (carbon sequestration and flood mitigation). GDP as is currently defined may give misleading signals as a measure of a region's economic performance and well-being due to its failure to explicitly and comprehensively account for the value of natural capital. As Repetto et al. (1989) summarize, "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." There are many other studies in literature which have covered this topic in greater details in the last couple of decades, for example, Boyd, 2007; Daly et al., 1989; Talberth and Bohara, 2006; and Stockhammer et al., 1997.

Comprehensive accounting methods of natural capital are given by UN's System of Environmental-Economic Accounting-Central Framework (SEEA-CF) and ecosystem services in the SEEA-Experimental

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[2] The SNA measures what takes place in the economy, between which agents, and for what purpose. At the heart of the SNA is the production of goods and services. These may be used for consumption in the period to which the accounts relate or may be accumulated for use in a later period. In simple terms, the amount of value added generated by production represents GDP (System of National Accounts, 2008 Parag. 1.6, UN et al., 2009).

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Ecosystem Accounts (SEEA-EEA). The stocks and flows of natural capital yield valuable environmental goods or services. The emphasis and interest to include natural capital and associated changes in natural stocks and flow of environmental services in nations' wealth accounting are growing. There is emerging recognition that SNA should indicate impacts of economic and other human activity on the environment, and how these impacts influence the availability of environmental goods and services. Different sectors of the economy depend on inputs for their production process from natural capital stock. The production cycle between the environment and the economy is especially critical for developing countries where natural capital makes up a significant share (36%) of total wealth (World Bank, 2012).

The concept of natural capital accounting has been around for more than 30 years. It was the seminal work of Repetto et al. (1989) at the World Resources Institute that attracted more focus on the subject. Agenda 21 of the 1992 United Nations Rio de Janeiro conference called for the establishment of a "program to develop national systems of integrated environmental and economic accounting in all countries". The 2012 Rio + 20 conference reconfirmed that "integrated social, economic and environmental data and information are important to decision making processes."

There has been increasing interest in natural capital accounting as a tool for natural resource and environmental management (Bartelmus, 2013; Obst and Vardon, 2014; UN et al., 2014b). The development of SEEA framework has been a huge step towards the realization of natural capital accounting.[3] However only a handful of countries have implemented or are in the process of implementing some form of natural capital accounting.[4]

Despite this considerable achievement, there are considerable challenges to deal with. In many countries, there is a lack of capacity for implementation of SNA itself. In some countries, it is a struggle to even assemble Social Accounting Matrices (SAMs) due to the poor quality of system of national accounts. In others, the presence/absence of supply-use tables and input-output matrices is another challenge.

Full integration of natural capital into SNA as outlined in SEEA framework that would link the environment and all sectors of the economy in one framework and the use of this framework for applied policy analysis demands in-depth knowledge of three different but closely-linked fields of economics: (1) natural capital valuation, (2) system of national accounts, and (3) computable general equilibrium (CGE) analysis. Whereas there are much analysis and applications that can be implemented with integrated accounts, extending this analysis further through CGE modeling framework provides more flexibility for economy-wide analysis platform.

Integration of natural capital into SNA in the form of input-output table (IOT) or its extended format in social accounting matrix (SAM) and its utilization for policy analysis in a CGE modeling framework will definitely provide a new methodological platform in this regard. Application of CGE modeling framework in natural capital accounting will meet the growing interest from natural resource policy makers and practitioners on the impacts of natural capital exploitation on the economy and vice versa. Policy makers will remain skeptical about the role of natural capital in the economy until they are able to see direct interrelationships between natural capital and economy in real world policy scenarios. To date, literature lacks a clear step-by-step methodology on how natural capital can be integrated into SNA and how this can be further used in CGE modeling framework for policy analysis. A research on the subject would provide much needed reference platform to undertake such work.

With the foregoing background, the objectives of this study are twofold: (1) to develop methodological framework for integrating natural capital from SEEA-CF structure into SNA; (2) to demonstrate a methodology of how natural capital data from a SEEA-CF study can be used for policy analysis in a CGE modeling framework; and the difference in economic impacts of policy shocks that natural capital integration into SNA can potentially bring about.

The remainder of this paper is structured as follows: Section 2 illustrates how monetary natural capital values can be integrated into the SNA (input-output table); Section 3 details how to use natural capital integrated-input-output dataset as a structural framework in formulating CGE model that can be used for assessing economic impacts of natural resource policy options. The last section summarizes the paper.

2. Integrating natural capital into system of national accounts

2.1. The input-output table structure

In this study, we use IOT data for CGE modeling. Under this subsection, we outline the elements (main accounts) of IOT and how they relate to each other. Input-output table or its expanded version in the form of social accounting matrix (SAM) (Pyatt and Round, 1985) is a widely used simplified segment of SNA for policy analysis and planning.[5]

IOT is a matrix representation of an economy's entire production system for a particular period of time, usually for calendar or financial year. It shows goods and services produced by each industry and how they are used by different users as either intermediate production inputs or final demand such as household and government consumptions or exports. IOT captures interactions of an economy with economies external to it through inclusion of imports on expenditure accounts and exports on receipt accounts. In a national IOT, these two trade accounts are commonly referred to as rest of the world account.

An IOT is normally presented in a rectangular matrix format. An IOT matrix does not show the interrelationship between value-added and final expenditures. By extending an IOT and showing an entire circular flow of income at the macro level, one captures the essential features of a SAM. In this paper, we focus on IOT. Fig. 1 illustrates a general structure of an IOT. The level of disaggregation of information in IOT depends on a number of considerations, primarily on data availability and purpose for which IOT is intended. Each column of IOT shows expenditures (cost) of an account while row gives receipts (income). Maintaining accounting identity, total of each row is equal to total of each corresponding column (X*n*).

An entry in row *i* and column *j* represents receipts of account *i* from account *j*. For instance in Fig. 1, X_{13} represents sales from sector 1 (receipt) to sector 3 (expenditures). The square matrix of producing and purchasing sectors (Sec1…SecN) represents intermediate input demand/sales.

[3] In 2012, the UN Statistical Commission adopted the System of Environmental-Economic Accounts Central Framework (SEEA-CF) that provides an internationally-agreed framework and standard to account for natural resources including minerals, timber, water, land, energy and fisheries (UN et al., 2014b), as well as accounts for public/private expenditure on environmental management and mitigation. Additionally, a separate set of guidelines for ecosystem accounting were released in 2013, the SEEA Experimental Ecosystem Accounting guidelines (SEEA-EEA) (UN et al., 2014a) for integrating complex biophysical data, tracking changes in ecosystems and linking those changes to economic and other human activity. The aim of SEEA-EEA is to provide an accounting framework for regulatory and cultural/aesthetic ecosystem services, which are non-market in nature, and give them a spatial dimension. SEEA-CF and SEEA-EEA were designed such that there is no overlap in the product space, so that double counting would be avoided.

[4] Some of these include: Botswana, Colombia, Costa Rica, Guatemala, Indonesia, Madagascar, the Philippines and Rwanda under the auspices of World Bank's Wealth Accounting and Valuation of Ecosystem Services (WAVES) partnership; other countries include Australia, Canada, Sweden, and Norway.

[5] Input-output tables are matrix representations of the goods and services account of the SNA. Other SNA accounts include: income, capital, financial, other changes in assets, balance sheet, and supply and use tables (System of National Accounts, 2008 Parag. 28.4, UN et al., 2009). IOT is typically compiled as an analytical extension in the SNA and is derived through the combination of supply and use tables (SUT) which are core accounts of the SNA. Various mathematical and analytical approaches are available to convert SUT to an IOT as outlined in The System of National Accounts, 2008 (UN et al., 2009; Trinh et al., 2012).