

Primary, Secondary and Tertiary Sector Linkages and Environmental Management

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Abstract

This paper attempts to implicitly establish a relation between the economy and the environment, and for that purpose, proposes that an understanding of resource management in the different sectors of an economy requires the use of techniques of dynamic optimisation. In this regard, the materials balance principle is considered as the underlying assumption, i.e., the treatment of residuals from an economic activity does not reduce their mass, but only alters their form. This idea of viewing the economic activity of different sectors as a comprehensive whole, integrated with its surroundings, traces the idea of industrial ecology. The author highlights certain activities of the primary, secondary and tertiary sectors and analyses in the light of optimum resource management. The discussion points out that although there is world-wide acceptance of the far-reaching impacts production and consumption activities on the physical environment that impose considerable costs on the economy - they still remain unaccounted in recorded statistics.

Key-Words : Resource management; Industrial Ecology; Materials Balance Principle; Input-Output system; Ecosystem services.

1. Introduction

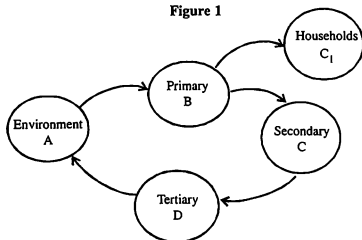
A paradigm shift in attitude towards environmental matters has been observed along with changes in values, ethics, morals and beliefs held by society as a consequence of urbanization and industrialization. The rise of environmentalism has influenced the views of the individuals and these have put pressure on business to change. But environmental policies require a clear understanding of relationships between basic economic activities - extraction, agriculture, manufacture, trade, services and the physical environment in which these activities take place. Appropriate policy measures demand a detailed analysis of the environmental impact of different sectors of the economy, closely related to each other. This paper makes an attempt to implicitly establish a relation between the economy and the environment. To get an understanding about resource management in the different sectors of an economy, one needs to use the techniques of dynamic optimisation. In doing this, the materials balance principle is considered the underlying assumption: the treatment of residuals from an economic activity does not reduce their mass, but only alters their form. This idea of viewing the economic activity of different sectors as a comprehensive whole, integrated with its surroundings, traces the idea of industrial ecology. The 'zero waste philosophy of industrial ecology is borrowed from the knowledge house of environmental economics to explain the input output relationship among the primary, secondary and tertiary sectors. In the last part of the paper certain activities of the three different sectors are analysed in the light of optimum resource management. The discussion brings to the front the fact that, in spite of the world-wide acceptance that production and consumption activities

have far reaching effects on the physical environment and that they impose considerable costs on the economy - they remain unaccounted in recorded statistics.

2. The Materials Balance Principle

The last two centuries have seen a changing balance in the share of employment, output, productivity and GDP attributable to primary, secondary and tertiary industry. Businesses in all these sector have been witness to several revolutions in technology, business structures and methods that have had important effects on the environment and environmentalism. The hallmark of pre-industrial economy is the dominance of primary production, particularly agriculture and the lack of industrial-urban infrastructure. As an economy develops, it undergoes a transition and business shift towards urban-industrial from rural-agriculture and eventually develop into a service sector dominated economy. The service sector, today, makes a considerable contribution to the economy of the world - which has changed the way it is viewed- specially with reference to a developing country like India. The concerns of environmentalism are now much wider than they were in the past and are meshed in hybrid issues together with social justice, democracy and human rights. The study of economic activities in relation to their physical environment can be based on the most simple form of the 'materials balance principle'¹ in which environment-economy interactions take place without any intermediation between the environment itself and final consumption sector. In this simplified situation it is presumed that no net accumulation of stock of goods takes place in the consumption sector, and the mass of inputs from the environment into consumption must equal the mass of residual discharges from the consumption sector to the environment. But a more complete portrayal may be obtained from Herfindahl and Knesse (1974). In this we find the physical interrelationships within an economy, taking into account the presence of intermediate production and recycling processes, where the zero sector provides the ecosystem services. Restoration and extension of natural ecosystems support the artificial ecosystem that is, the agriculture sector. The basic primary sector inputs are derived from agriculture and some are the outputs of extraction (food grains, ores, liquids and gasses). In the secondary manufacturing sector, these are converted into useful products for human consumption (basic fuel, food, raw material for production).

Figure 1



The outputs of these processes of the secondary sector become the inputs of the tertiary sector - taken up for utilisation by other firms and house holds. Returning to the materials balancing principle, the flow of mass materials from the environment A is equal to the mass of residual discharge flows to the environment that is, B, C, and D (Figure 1). But as a corollary, the mass of residual discharges is larger than the mass involved in basic material s production, the difference being accounted for by the oxygen consumed.

On the other hand, the materials balance principle shows that treatment of residuals from economic activity does not reduce their mass, but merely alters their form.ⁱⁱ In an economy, therefore, while it is important to be clear that waste treatment does not indicate 'getting rid of waste', but consider the forms of discharge and modify their impacts on the environment. This brings one to one of the most important concepts of industrial ecology. Like the biological system, it rejects the concept of waste. Dictionaries define waste as useless or worthless material. In nature, however, nothing is eternally discarded: in various ways all materials are reused, generally with great efficiency. Nature has adopted this approach because acquiring these materials from their reservoirs is costly in terms of energy and resources and thus something to be avoided whenever possible. In our industrial world, discarding materials wrestled from the earth system at great cost is also generally unwise. Hence, materials and products that are obsolete should be termed residues rather than wastes. It may therefore be recognized that wastes are merely residues that our economy has not yet learned to use efficiently. But studies under the subject of industrial ecology show that wastes may also be viewed as outputs of one process being adopted by the next - leading to sustainable economic activities.

3. Industrial Ecology

Industrial ecology is the means by which humanity can deliberately and rationally approach and maintain a desirable carrying capacity, given continued economic, cultural and technological evolution. The concept requires that an industrial system of an economy be viewed not in isolation from its surrounding systems but in concert with them. No firm exists in vacuum. Every industrial activity is linked to thousands of other transactions and activities and to their environmental impacts.

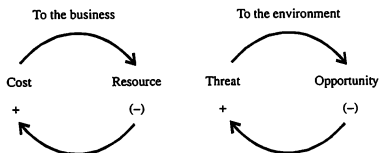
Industrial ecology provides a powerful prism through which to examine the impact of industry and technology and associated changes in society and economy in the biophysical environment. It examines local, regional and global uses and flows of materials and energy in different sectors of an economy.

Industrial ecology is an attempt by environmentalists to replicate natural sustainable systems into industrial systems. It involves the application of natural 'zero-waste' ecological process to industryⁱⁱⁱ. Jelewski^{iv} et al (1992) describe industrial ecology as 'a new approach to the industrial design of products and processes and the implementation of sustainable manufacturing strategies. It is a concept in which the industrial system is viewed, not in isolation from its surrounding systems, but in concert with them. Industrial ecology seems to optimise the total material cycle from virgin material to finished material, to component, to product, to waste product and to ultimate disposal.

The concept of industrial ecology is based on the self-sustained biological ecosystem ecologically sustainable economy would consist of an industrial system structured as a network of several 'interacting niches'^v. It is a series of interconnected process, whereby the different sectors of the economy - primary, secondary and tertiary generate output from one sector to be used as the input of the other. In order to be a successful ecologically sustainable economy, it may be modelled on the industrial ecology concept of minimising energy and material inputs as well as waste outputs. Industrial ecology can take under its wings all economic activities in the form of extraction, agriculture, manufacturing and services. Experience of the 'industrial symbiosis' followed in an industrial estate at Kalundborg in Denmark^{vi} successfully integrating different economic units from three separate sectors of the economy in a sustainable manner requires that the industries must differ in terms of material variety and intensity and yet must fit together. Since the economic units are not charitable in their mission, yet environmentally conscious, their negotiated deals must be viable to both parties. The presence of a supervisory and control authority to monitor these transactions in the form of local authorities is essential in order to achieve an integrated and sustainable economy modelled on the lines of industrial ecology.

These ideas of implementing the self balancing philosophy of the natural ecosystem into the industrial development matrix of a nation takes a fresh look at how the business sector and environmentalists are finally moving closer - towards the final destruction of an ecologically sustainable industrial economy. To understand the complete relationship between business and the environment it is necessary to understand both the way in which the environment influences business as well as the ways in which various industries change the environment. There is a wide spectrum of attitudes between seeing these relationship in a positive or negative light. The aim of industrial ecology is to bridge this gap and bring about the naturally self- sustaining character of the ecology into the business dynamics. Business may see environment as either a cost of a resource where as the environmentalist may see business as a threat or as an opportunity (Figure 2).

Figure 2



The implementation of the philosophy of industrial ecology is a way in which business sector and the environment can come together. One of the ways of describing and analysing the interaction between the environment and the economy indicated in the materials balancing principle is with the use of the input output models. The main reason behind use of such input

output relationship is to use the flow chart between different sectors of the economy. The statistical foundation for the development of such models may be laid by the use of input output tables. In fact, an input output table is essentially a very detailed form of national accounts. Therefore, it may be considered that sensible and effective environmental policies require an understanding of the relationships between the different sectors of the economy and the physical environment in which the interactions take place.

There is enough scientific evidence to establish that measures of environmental protection are essential or prudent for all forms of business activities operating in different sectors of the economy.

4. Environmental Management by Input-Output System

Consequently, there is an attempt by business to incorporate the environment into its agenda on its own terms. The environment is regarded as a legitimate and unavoidable area of concern, but the concern is primarily for the well - being of the business and not the environment. Ecological ideas are incorporated into the business, which Welford (1997)^{vii} has seemed as 'corporate hijacking of environmentalism'. Unable to ignore or refute the concerns of the shareholders or the government over the need to 'do something', the different sectors of the economy have attempted to bring the environment in their Board Room decisions. Such business practices are often referred to as ecological modernization - summed up in the phrase 'pollution prevention pays'. It is attractive to business because by way of making environmental improvements they also stand to gain stakeholders' appreciation. Industrial ecology gives rise to such modernization methodologies, which seek to resolve the pollution and waste problem, absorbing industrial processes. Unlike the 'end-of-the-pipe' problems, where environmentalists were the watchdogs, themes of partnerships are proposed between the different sectors of the economy. This approach to environmental management of business regards economic growth and environmental protection as compatible.

The concept of ecological modernization is often criticized by the theorists of industrial ecology because although it may result in more efficient use of resources, it still stimulates the growth of consumption (which contradicts the philosophy of industrial ecology of limiting energy and input use) and may therefore be an attempt at postponing the ecological crisis rather than solving it. But ecological modernization has a practical side to it, which stresses on innovation — in technological or managerial terms in a comprehensive manner encompassing the economy as a whole.

The modernized industrial ecology concept would aim at development of integrated resource management systems across primary, secondary and tertiary sections of the economy. Arising at a sustainable management practice, waste diversion and recycling strategies also need to be structured. Alongside research and development of appropriate technologies relating to each sector, considering its impact on the preceding or succeeding sector would provide the necessary rehabilitation of the natural resource bases systems. On the whole, effects are to made for building and rebuilding natural and acquired resilience.

The vision statement for an economy aiming at ecologically sustainable development is the creation of a comprehensive national and regional framework which would satisfy the

requirements of the product cycle management and ensure that sustainable waste management systems adopt a utilisation approach towards resource conservation. Waste, is not viewed as an item to be disposed but more as a resource to be put to use by the succeeding sector of the economy. The paradigm shift in the concept of 'waste' has a different image and perspective in the integrated scheme of resource management of the primary, secondary and tertiary sectors.

In the light of the modernized industrial ecology the inter-industry transactions are discussed from the point of view of the input-output systems. There are three types of linkages between the economy and the environment. First, economic agents exploit the natural ecology - forming the core of the zero sector. The natural resources are extracted in the primary sector by the mode of agriculture, mining or fishing. In less obvious ways, the primary sector also 'consumes' fresh air and landscape. The processing and consumption of these environmental resources yields residuals which are returned to the environment and which may have undesirable economic, social or health effects, such as air pollution or soil degradation. Attempts to eliminate or compensate for these effects leads one to the third tertiary sector - concerned with environmental renewal.

The basic input output methodology, developed by Wassily Leontiff assumes constant returns to scale and permits no substitution between inputs. A schematic framework has been developed by Perman et al. (1997) for an extended input output system. This can be adapted to a range model of variants depending upon the purpose of model and data availability (Figure 3).

Figure 3

	Industries 1,2.....n	Abatement	Final Buyers
Stock of natural resources	II	V	VIII
	I	IV	VII
Residuals	III	VI	IX

Source: Perman, Ma and Mc Gilvray, 1997

The figure brings to focus the close interaction between the different sectors of the economy and portrays the depth of interrelationship. It also indicates that efficient resource management in each of the sectors is important in absolute terms because of the networking effect between them. It also brings to the forefront the fact that unless environment conscious activities in each of the sectors are coordinated with the other sectors, the entire effect will remain fruitless.

The sub-matrices I and VII record flow of goods and services between n intermediate sectors of the economy; II records the extraction of natural resources by the industries; III records residual wastes generated by each industry; IV, V and VI represent residuals abatement or treatment activities. The final column consisting of sub-matrices VII, VIII and IX records sale or delivery to buyers.

5. Sector Zero: Ecosystem Services

The initiation of the modernised version of industrial ecology sets in form restoration and extension of natural ecosystems^{viii}. For a balanced approach to industrial ecology greater emphasis need to be placed on management of ecological communities and the prevention of threat to such communities and industrial species. This preventive approach shall be supplemented by recovery programmes that are designed, preferably indigenously, for the threatened species. Wilderness style management may be also be increasingly viewed in natural environments, being the most cost effective strategy for management of sector zero resources at a wider level. Artificial ecosystems such as agricultural ecosystems need to be modified so that they could perform the nature conservation functions. In addition agriculture needs to be complete the eco-cycle of the natural systems they had replaced. Efforts also need to be made to strengthen on re-introduce natural or quasi-natural ecosystem into the city to manager the flow and purification of drainage water. This would directly or indirectly provide for greater aesthetic and nature conservation benefits.

6. Primary Sector

The primary sector consists of businesses that utilize a natural resources directly as the main purpose of its activities. It may harvest directly from the wild (deep sea fishing, forestry), cultivate crops (agriculture), raise domesticated animals (ranching), extract minerals and fuels from the earth (oil drilling) or tap naturally renewable source of energy from the environment (wind power). Environmental responsibilities of corporates operating in primary sector is of utmost significance because of their close relationship with their environment. Their very existence is bound up with natural resources and has chain interaction with other sectors as may be seen in Figure 4.

Figure 4: Primary Sector: Production and Extraction

Zero	Primary	Secondary	Tertiary
	Direct produce	Industrial supply	Farm tourism
Set aside for nature conservation	Organic farming Agro forestry	Exotic-hybrid farm enterprise	
Adapted from: Bateman and Ray, 1994			

Responsibility of businesses operating in the primary sector encompasses their use of renewable and non-renewable resources. Renewable resources are those that are capable of self-regeneration and could go on indefinitely (at least in theory). Provided the rate of extraction equals the rate of renewal, the resource will remain in a steady state and hence sustainable. But if the rate of extraction exceeds the rate of renewal, the stock of resource will go into a decline and eventually disappear. Nonrenewable resources have a finite life. For all practical purposes they can be considered to be finite in stock, which can be depleted or conserved but not increased. Effective management of both these resources are, therefore, the responsibility of the corporates dealing in them, from two different perspectives.

Renewable resources need careful management to ensure their replenishments. It is the responsibility of businesses using such renewable resources (e.g. fish) to manage them in a sustainable way in the lines of sustainable agriculture or sustainable forestry.

Business houses using non-renewable resources like minerals or fossil fuels are responsible for their effective management because efficient use of these resources can prolong their lifetimes. Managers of businesses which use fossil fuels can plan to effectively substitute them by alternate renewable energy resources.

Businesses engaged in primary sector are responsible for using latest technological developments like precision farming to make their activities truly environment friendly. Precision farming is a package which involves detailed mapping of field of fields to reveal micro-spatial variations in nutrient status so machinery can apply the optimum quantity of fertilizer in exactly the right locations. Precision farming is claimed to be highly effective in cutting costs, cutting pollution and steel maintaining or even increasing yields.

Agri-businesses can also engage in 'pluriactivity' by which a business takes up variety of income generating environment friendly activities using a resource of the business or skills of the business, but different from the main activity of the organization for example, farm tourism is a potentially beneficial activity only when responsible businesses are careful about maintaining the ecological balance of the farm inspite of tourist influx.

7. Secondary Sector

In the businesses belonging to the secondary sector, manufacturing being the core of such sector, raw materials and components are brought together and manufactured into either an end product or a component for some other manufacturing process. The environmental responsibility of the corporate engaged in this sector is particularly important because many such industry handle hazardous, toxic or environmentally sensitive material. Most of these industries dealing in heavy, chemical metal smelting, textiles, paper pulp, leather tanning have potential to create considerable pollution for the environment. The disposal of organic wastes from these processes inevitably causes considerable disruption to eco system.

The manufacturing industries use processes that are associated with these distinct stages in environmental terms. First, raw materials are selected and brought together for manufacture. Second, the actual manufacturing process has the potential to pollute and produce waste materials. Third, there are environmental considerations even after these products are sold with respect to their disposal and possible recycling.

Considering the first phase, i.e., collection of resources - materials, energy, labour, knowledge, the responsibility of the business lies primarily in managing these resources so as to prevent their adverse impact on the cost of production. As resources are used up and they become scarce, there is tendency for price to rise for quality of the resources to decline. Inferior quality inputs require greater energy to be processed. Therefore, it becomes the responsibility of such manufacturing concerns to look for and research upon to develop alternative environment friendly resources and components for their product (e.g. use of synthetic wood in furniture industry).

The second phase of manufacturing activity invariably produces waste products and pollution. Waste products can be considered to be conservative and non-conservative. Conservative waste products are those which dissipate through the environment, for example, heavy metals which find their way into water courses, tend to accumulate in estuarine mud. The responsibility of businesses in such cases revolves around maintaining seconds of total amount of waste dumped and the social costs of their prolonged exposure and accumulation on the environment. Non-conservative wastes are capable of being broken down by natural processes. Though there is zero cost for the discharge of such wastes, the corporate responsibility lies in restricting the limits of such wastes to the amounts which is possible to be assimilated into the environment.

In the third phase the manufacturer's responsibility is more clearly defined - it must be fit to pass the test of consumer legislation. The responsibility of the business stretches even after the point of sale satisfying all environmental and legal regulations. The business is responsible for indicate on the diverse where the component can be recycled. It is also responsible for collection and subsequent of these. Manufacturers therefore, through the design products can influence the environmental impact of products long after they have left the factory gates.

The manufacturers environmental possibilities are directed towards reduction in the use of resources, energy, waste and harmful pollution and promote recycling and reuse of finished products. Their responsibilities are directed towards pollution reduction, recycling and resource conservation. In this there is a close line between doing as little as possible and complying with regulations and doing nothing and taking the risk of prosecution. But the core responsibility of the manufacturer stretches beyond compliance.

8. Tertiary Sector

Despite of the growing dominance of the tertiary industries in all parts of the world and especially the developed world, relatively little attention has been given to either their impact on the environment and how they fulfill their responsibilities in these lines. This is primarily because in comparison to agriculture or manufacturing they appear to depend less on physical resources for their basic operation. Their impact on the environment is also less obvious because they unusually deal with more intangible products, but their relationship with other sectors of the economy is no less explicit as may be seen in Figure 5.

Figure 5: Tertiary Sector: Human and Physical Services

Zero	Primary	Secondary	Tertiary
Conservation of Greenfield sites	Landscaping	On site recycling	Environmental audits
Renewable materials usage	Recycle products	Organic production process	Educating customers
		Sustainable packaging	Awareness generation
Adapted from: Blaer and Hitchcock, 2001			

Those industries, like retailing, transport, property development and tourism utilize the physical environment directly. Whereas, finance, telecommunications and public administration generally deal in intangibles and contribute to pollution through travel of their employees and clients, produce waste from canteens, produce paper waste and consume water and materials. Retailers often take up large spaces and displace other uses, which have a visual impact on landscape. Their customer fleet creates environmental impact in the form of land and water use pollution from traffic and energy use.

Retailers can adopt a variety of green operations in their attempt at cost cutting, efforts in image building or achieving sustainability. To be successful environmental considerations need to be integrated in all aspects of the business. It is the responsibility of the retailer to act as an educator and encourage his customers to participate voluntarily in environmentally responsible activities. Retailers are often criticized on the grounds of selling up shopping malls in greenfield sites in rural areas, thereby generating pollution in formerly tranquil areas. Such stores should therefore, bear their responsibility of maintaining environmentally friendly situations around the store. Retailers can also fulfill their environmental responsibility by strongly influencing or dictating suppliers into producing green products. A green product should be from a sustainable resource, durable, capable of recycling, pose minimal hazards to environment in production, transport, sale, use or after use.

Some retailers can fulfill their responsibility towards the environment and at the same time turn it into a competitive advantage. They may market themselves on green niche retailing taking pioneering examples from Body Shop. Such retailers promote their environmental responsibility as one by which they showcase their responsibility of providing green products and incorporate green planning into its mainstream activities when larger retailers begin such movements - it has chances of widespread adoption.

9. Conclusion

Many of the analytical and policy issues discussed here relating to the environment require scholars to model the interaction between the economy and environment. That has been attempted here but such analysis of interrelationships between different sectors of the economy and its physical environment is theoretical in nature and would carry contemporary meaning if represented through the national accounts figures. However, this leads one to ponder whether and if at all, in what ways the system of national accounts may be modified or extended to include the environment economy interaction. The specific criticism that may be raised is that the System of National Accounts do not include estimates of the depletion in the nation's stock of natural resources, such as the forests (renewable) or coal (non renewable) and may therefore be said to underestimate the amount required to maintain the nation's capital stock and to over estimate net national product or national income. Successful development of any field of applied service is dependent on observation, measurement and recording scientific data. The systematic compilation of environmental statistics has been taken up by many countries, albeit with great variations - in the absence of internationally agreed system of classification. There is serious dearth of environmental data expressed in value terms, which would permit the application of economic calculations to environmental issues. Thus there is a clarion call that the conventional national accounts aggregates, such as gross domestic product and national income, need to record the consumption and depletion of national assets.

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- i The materials balance principle concerns identities that may hold between physical flows in any closed system, given the Laws of Thermodynamics. In simple words, the principle states that the mass of residuals that flows into the environment from all forms of activity in the system equals the mass of resource flows from the environment
- ii this is a consequence of the Law of Conservation of mass - matter cannot be created or destroyed, although its form can be altered.
- iii Mookerjee, Kanika, 1997, *Coming Clean with Life Cycle stewardship*; in *Studies in Finance and Accounting*, ed AK Basu, K Mookherjee and S. K. Chakraborty; Department of Commerce, University of Calcutta

- iv Jelewski, L. W. Graedel, T. E. Landdise
- v Ayres and Ayres, 1996
- vi Frosch and Gallopoulos, 1989
- vii Welford, R, 1997, Hijacking Environmentalism, Corporate Responses to Sustainable Development, Earthscan, London
- viii Major efforts need to be made to restore this sector after the massive reductions caused since the European colonization of Australia.