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Analysis

India's biophysical economy, 1961–2008. Sustainability in a national and global context

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ABSTRACT

India's economic growth in the last decade has raised several concerns in terms of its present and future resource demands for materials and energy. While per capita resource consumption is still extremely modest but on the rise, its sheer population qualifies India as a fast growing giant with material and energy throughput that is growing rapidly . If such national and local trends continue, the challenges for regional, national as well as global sustainability are immense in terms of future resource availability, social conflicts, pressure on land and ecosystems and atmospheric emissions. Using the concepts of social metabolism and material flow analysis, this paper presents an original study quantifying resource use trajectories for India from 1961 up to 2008. We argue for India's need to grow in order to be able to provide a reasonable material standard of living for its vast population. To this end, the challenge is in avoiding the precarious path so far followed by industrialised countries in Europe and Asia, but to opt for a regime shift towards sustainability in terms of resource use by building on a host of promising examples and taking opportunities of existing niches to make India a trendsetter.

1. Introduction

Within the ongoing discourse on global sustainability, India has come to feature rather prominently with its unequivocal message of attaining a higher material standard of living for its population by 2025, at par with industrialised nations. There has actually been an increase in industrial activity and income in the last decade. Demanding an increased share of the world's resources by invoking the language of environmental justice, India has leashed forward a development policy that demands more environmental space to grow (Planning Commission, 2002, 2006). Obviously, this has not, and will not come without ecological consequences, both to its domestic as well as to the global environment (European Commission, 2009).

The basis for India's arguments comes from its unequal share in the consumption of the world's resources. With a population that is almost one-fifth of the global total, India in 2008 used only 7% of the global supply of material resources (in terms of mass) and 5% of global primary energy supply (Krausmann et al., 2009; Steinberger et al., 2010; The World Bank Group, 2012). Its share in the use of key resources of industrialisation such as petroleum or copper is even smaller. Even though India's per capita level of resource use and emissions is strikingly low, India's resource requirements are by far not negligible. For example, India is the world's fourth largest energy consumer and is third, after China and the US, when it comes to global carbon emissions (Marland et al., 2007; The World Bank Group, 2012, CDIAC data at http://cdiac.ornl.gov/). The challenge for India, therefore, is to be able to meet its development goals and resource requirements in a sustainable way.

As India is on its way to industrialise, the question remains to what extent this may be possible following the same pattern of industrialisation of the West that had occurred under very different conditions, namely, the benefit of cheap raw materials and labour from colonies and the abundance of fossil energy reserves accessible at low cost. Given the fact that India is still in the early phases of a metabolic transition from an agrarian to an industrial resource regime (Krausmann et al., 2008b), there are reasons for concern on how this process may continue within given biophysical constraints. On the other hand, being a latecomer opens up opportunities for India to learn from past mistakes, experiment with innovative pathways with high sustainability potential and to become a trendsetter for sustainability.

This paper is an original study to explore some of the challenges faced by India and tries to interpret the meaning of its development rhetoric in a biophysical sense.[1] To be able to understand India's

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[1] This is the first detailed Material Flow Analysis (MFA) for India covering such a long time period. The data presented in this paper are available for download at: http://www.uni-klu.ac.at/socec/inhalt/1088.htm. MFA data for India are also included in a study for the Asia Pacific region (Schandl and West, 2010, see also UNEP, 2011).

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future sustainability challenges, we investigate its social or industrial metabolism, using the material and energy flow accounting framework (Ayres and Simonis, 1994; Fischer-Kowalski and Haberl, 2007; Haberl et al., 2004). Some of the derived indicators calculated are also presented in relation to GDP to better understand the relationship between the economy and biophysical flows. Finally, the paper attempts to evaluate these trends in a global context and what this might mean in terms of future global resource extraction and sustainability.

2. India's economic policy and development since independence

At the time of independence in 1947, India inherited an economy that was predominantly agrarian with 70% of the workforce in the agriculture sector that contributed to half of the country's total national income. Industry was poorly developed, dependency on imports was high that provided little impulse for economic growth. As the population grew, pressure on land for producing food increased. Low levels of industrialisation, low labour productivity and agricultural output and under-employment contributed to a low national income. The Industrial Policy Resolution of 1948 under India's first Prime Minister, Jawaharlal Nehru, was in favour of rapid economic development and aimed to increase national savings with the state playing a key role. Agriculture remained the main instrument for addressing poverty in the rural areas and for improving food security for the infant nation. But most of the industrial production and manufacturing was state owned (such as mining, iron and steel, energy, infrastructure, communication, defence) and only a small number of industrial categories were left to the private sector.

Even so, up until the early 1980s, private industrial production was state controlled, which imposed severe barriers to the growth of firms with quantitative restrictions on the production of goods, imports and exports, levied through heavy taxation and licence fees. Influenced by the socialist thinking of Russia towards which India was inclined, the ideology was in favour of moderate consumption as against accumulation or the use of “luxury goods.” While necessities such as food and textiles were cheaply available, industrial goods such as televisions, cars, scooters, refrigerators were heavily taxed. The other reason was to reduce reliance on the import of energy and machinery since national savings was a major concern.

A large body of literature exists on the inefficiency of India's industrial policy that gripped the nation until the early 1980s (Ahluwalia, 1985; Basu, 2007; Jalan, 1992). The stagnation of industrial production was attributed to low productivity and quality, high costs, obsolete technology and corruption in the license system. While India debated hesitatingly on its industrial reforms during the 80s, China doubled its GDP between 1978 and 1991. Close to an economic crisis and bankruptcy in 1991, India was forced to opt for a more liberal regime under Prime Minister P.V. Narasimha Rao that led to the dismantling of the license system, reduction of tariffs and dispensing of quantitative controls on imports. All in all, the new policy contributed to opening up more areas for the private sector, foster a competitive environment, uncontrolled production, and opening up to foreign investments, in particular for infrastructure and export-oriented sectors.[2]

3. Concepts, methods and data sources

We use the concept of social or industrial metabolism (Ayres and Simonis, 1994) and the corresponding methodology of material flow accounting (MFA) to investigate changes in India's biophysical economy, compatible to standard monetary system of accounts (Fischer-Kowalski et al., 2011). Following this approach, we aim at analysing the ecological “embeddedness” of India's socioeconomic system (Martinez-Alier, 1999). We refer to current standards of economy wide material flow accounting (Eurostat, 2009; OECD, 2008) to quantify domestic extraction (DE) of all raw materials and biomass harvested, their imports and exports and to derive aggregate headline indicators in physical units (mass and energy):

- *Domestic material consumption* (DMC) measures the apparent consumption of materials in an economy and is defined as the sum of DE and imports minus exports. It has been argued that DMC also equals the waste potential of an economy in the long run.
- The *Physical Trade Balance* (PTB) measures the physical net trade of a country and is defined as imports minus exports in physical units. Negative values indicate net exports.
- *Material Intensity* (MI) measures the amount of materials required to produce one unit of GDP and is defined here as DMC per GDP. It is the inverse of material productivity.

In this paper we discuss data and indicators at an aggregate level, distinguishing between the four main material groups: biomass, fossil energy carriers, ores and industrial minerals and construction minerals. Fossil energy carriers, ores, industrial and construction minerals are also subsumed under mineral and fossil materials as opposed to biomass. In some cases we also refer to a more detailed split of material groups.

The material flow database we established for India follows the structure proposed by Eurostat (2009) and, at the most detailed level, includes data on the yearly mass flows of 50–70 material groups. It covers the time period 1961 to 2008. We used international statistical sources, but cross-checked international data with national statistical sources where possible for some points in time. Main sources for these cross-checks were the Indian Statistical Abstracts series (CSO, 1966, and other years).

For the domestic extraction of biomass we used data from FAOSTAT (FAO, 2005; FAO, 2009) for harvest of crops, fuelwood and timber, as well as fish capture. The amount of used crop residues was estimated by using region specific harvest indices and recovery rates for major crops (Krausmann et al., 2008a). We calculated dry matter feed balances to estimate grazed biomass and roughage extraction by applying a “grazing gap” method, i.e. assuming the difference between total feed demand and market feed supply being covered by grazing (Eurostat, 2009; Krausmann et al., 2008a). Livestock numbers were drawn from the FAO (2009). Feed demand was estimated by using livestock numbers from FAO (2009) and species-specific feed intake factors reflecting changes in livestock productivity over time (changes in milk yield, live weight; see Krausmann et al., 2008a; Wirsenius, 2003). Market feed supply was calculated based on statistical data (FAOSTAT, 2010).

Data on the domestic extraction of fossil energy carriers was obtained from the International Energy Agency (IEA, 2007; IEA, 2010) for the extraction of coal, petroleum and natural gas for the period 1970 to 2008 and UN statistics (UN, 2007) for the period 1961 to 1970. For the domestic extraction of ores and industrial minerals the main sources were the United States Geological Survey (USGS, 2008 and other years) and the United Nations (UN, 2007). We used region specific information on coupled production and ore grades derived from US databases (United States Bureau of Mines, 1987; USGS, 2008) to extrapolate the amount of extracted gross ore from reported metal/mineral content.

Construction minerals comprise mostly of sand, gravel and crushed stone. None of these materials are reported in national or international production statistics. We estimated the use of natural aggregates by applying a procedure discussed and applied in recent MFA studies (Krausmann et al., 2009; Schandl and West, 2010). This method allows a quantification of limestone extraction for cement production and of sand and gravel used for concrete and asphalt production on

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[2] In 2005, agriculture still engaged 56% of the total work force contributing 19% to the nation's GDP. Industry and services, on the other hand, employ 19% and 25% of the labour force respectively contributing 27.4% and 53.6% respectively to India's GDP (Asian Development Bank, 2007).