Green Asia country report: India

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1 Policy summary

Development planning in India would benefit from a strong focus on the principles of sustainable consumption and production to guide investments into institutions, policies and strategies to manage the country’s transition to a middle income economy in a way commensurate with the SDGs.

1) India still has low material and energy inputs on a per capita basis, especially when adjusted to take account of where final consumption actually takes place. India's current level of material footprint per capita, at around four tonnes, is just over a quarter the level generally required to achieve a high level of human development. Given this, it is important that any general "messages" regarding the path to more sustainable development be tempered by the reality that India, in common with most SWITCH-Asia countries, is currently consuming much less than it will ultimately need to. While making efforts to improve the efficiency with which materials are used is always a central and appropriate recommendation to any government, in the case of countries like India this message should not be extended to suggest that it is also possible, or even desirable, for them to consider reducing or even stabilizing their absolute levels of consumption at this point or in the near future. Such goals probably only make sense for nations above a level of 15 tonnes of material footprint per capita. There needs to be convergence between current low income and high income countries in terms of their resource availability, albeit at a level much lower than current high income countries rely upon.

2) The current level of urbanization in India is relatively low, and urban housing and transport infrastructure is lacking. Future growth of India’s cities can be expected and it will be important for the country to invest in built and transport infrastructure that, as far as possible, implements design principles and technologies that will create sustainable and liveable cities. There is a window of opportunity, if policies and standards are set appropriately, to achieve good urban outcomes that will have a lasting legacy for the attractiveness and competitive strength of India's cities. Cities are also the places where changes in incomes, lifestyles and consumption occur first and embarking on policies, examples and practices that facilitate environmentally sustainable consumption behaviours early in the transition process would be beneficial for the country.

3) India's low per capita material and energy consumption is combined with a relatively high population density, so the intensity of environmental impacts is about average for a SWITCH-Asia country. This means that as India increases either its population or per capita materials and energy use, it will rapidly incur environmental loadings above the average for SWITCH-Asia countries. This can only be offset by increasing resource efficiency. India is one of the most constrained SWITCH-Asia countries in this regard, and so one where it is particularly urgent to consider the balance between the social and economic benefits achieved (including resource security), by expanding local extractive industries, or offshoring the more materials and energy intensive production processes as far as possible, and concentrating on more labour intensive / higher value adding activities locally.
4) The earlier options for moving up value adding chains are considered, the better. This is because the physical and social infrastructure appropriate for continued expansion of primary industries for export will, in many cases, be different to that required for using those resources as inputs to local secondary industry. In addition to the possibility of being "locked in" to infrastructure inappropriate for further value adding, elements of institutional and contractual lock in will also occur. Land tenure arrangements most suitable to encourage expansion in forestry may disadvantage other primary industries (or an area’s value for tourism), and vice versa. Also, while the development of a new local extractive enterprise can provide opportunities for the development of other local industries, if the output is fully committed to export via long-term supply contracts it is effectively lost as a potential input to local industry.

5) India is in the rapid acceleration phase of the socio-metabolic transition from an advanced agrarian to an industrial society. To ensure that this transition takes place in a manner sustainable over the long term, the country must take advantage of the local tertiary education system's ability to deliver expertise relating to green growth. Given that India already has a large and capable tertiary education sector, a more important task may be expanding the capacity of vocational education programmes. This needs to be able to produce large numbers of skilled workers with the technical expertise necessary to competently use the modern materials and techniques required build the most environmentally and socially sustainable infrastructure.
2 Introduction

India ranked around the middle of the SWITCH-Asia group in terms of GDP and population growth over the study period. While GDP per capita increased almost fivefold, India ended the study period ranking only slightly higher among the SWITCH-Asia group on this basis, 10th of 17 in 2015 compared to 12th of 17 in 1970.

India was in the medium human development category (as measured by UNDP) in 2013, with an HDI of 0.59, a life expectancy of 66.4 years and a mean of 4.4 years of schooling (UNDP, 2014). GDP per capita was $1170 (US$ constant 2005 exchange rate basis).

The growth of three key economic indicators for India since 1970 is shown in Figure 1. There was a major change in economic growth regimes before and after a period of economic liberalization which commenced in 1991. The growth rate from 1970 to 1991 averaged 4.2% p.a. compounding, a rate which increased to 6.7% between 1991 and 2013. In contrast, the rate of population growth slowed, so that the contrast between the earlier and later periods with regard to affluence was even greater, with GDP per capita growth of 1.9% p.a. over the earlier period more than doubling to 5.0% p.a. over the post-liberalization period.

The rapid growth since the early 1990s was accompanied by some changes in the underlying structure of the economy. From data in UNSD (2015) it can be ascertained that the importance of the value added in the combined agriculture, hunting, forestry, and fishing sectors decreased greatly, from 29% of GDP in 1990 to 13% in 2013, although the total value added in these sectors almost doubled over that period. The combined transport, storage and communications sector increased its share from 4% to 9% of GDP, while the wholesale, retail trade, restaurants and hotels sector increased its share from 11% to 15%. Manufacturing remained constant in share terms, at 14%, while quadrupling in absolute terms over the same period.

![Figure 1 GDP, population and affluence (GDP per capita) for India, indexed (1970=100)](image_url)
Household consumption's share of domestic final demand\(^1\) decreased from 63% in 1990 to 56% in 2013, while capital investment increased from 25% to 34%. Government consumption decreased somewhat (in share terms) from 12% to 10% of domestic final demand, while increasing 276% in absolute terms.

The trends described above imply that some of the short-term gains in living standards that could have been realized by higher consumption in the present have been deferred and channelled into investment for the future, although not to the extent seen in some other SWITCH-Asia countries. While retarding improvements in material living standards in the short term, in what remains a poor country, the bias towards investment should strengthen India's growth and improve productivity over the longer term.

India’s exposure to trade grew very strongly between 1990 and 2013, with exports of goods and services increasing by a factor of almost 16, and imports by a factor of over 17. This rapid proportional increase made the role of international trade much more significant in the Indian economy. Where in 1990 combined imports and exports had been equivalent to approximately 14% of GDP, by 2013 this had increased to 54\(^2\). The ratio of exports to imports, already less than 1:1, moved slightly further against exports, with India earning $0.82 from exports for every dollar spent on imports by 2013. Whether this develops into an ongoing trade deficit, or is linked to current productive investments which will ultimately rebalance exports and imports, is not clear.

Exchange rate based GDP per capita values tend to greatly understate local purchasing ability for low income countries, so a purchasing power parity (PPP) basis has been provided as well, in Figure 2. Here we see that India’s exchange rate based GDP per capita of US$1170 in 2013 actually had a local purchasing power almost five times that, equivalent to $5759 spent in the US. This is important in establishing a more realistic idea of the real material living standards achievable locally.

\(^1\) Domestic final demand is defined as Final consumption + Gross capital formation. It excludes demand required to produce exports, and the complex webs of intermediate demand required among the industries to produce goods and service at stages prior to their final consumption or investment.

\(^2\) An important qualification here is that, for poorer countries, using exchange rate currency units will tend to exaggerate the real economic activity associated with exports/imports compared to that for domestic consumption. While an exchange rate basis is appropriate for quantifying international trade, the level of economic activity which underpins the domestic economic activity would perhaps be better reflected by purchasing power parity (PPP) measures.
Figure 2: Affluence compared on constant 2005 exchange rate versus purchasing power parity basis for India.
3 Material use, waste, material efficiency, trade dependency and extractive pressure

Material inputs increased greatly over the studied period, with a period of particularly rapid growth notable in the earlier part of the new millennium. This rapid growth has been accompanied by a rapid shift in the underlying mix of materials, in a pattern highly characteristic of a nation undergoing the socio-metabolic transition away from the biomass-based materials and energy systems of an agrarian society, towards the minerals-based systems of an industrialized society.

Material inputs to India's economy were, in aggregate, dominated by domestic extraction for the entire period 1970 to 2015, although the importance of imports grew from 2% at the beginning of the period to 9% by the end. This level of independence from imports holds for all individual materials categories except fossil fuels, where imports constituted 50% of DMI by 2010, up from 20% in 1970. The materials category where India is most independent of imports is biomass, where they constitute only 1% of DMI.

Figure 3 illustrates the extent to which the Indian economy has moved away from dependence on inputs of biomass, in share terms, even as absolute levels of biomass input continued to grow. Biomass' share of DMI almost halved from 74% in 1970 to 38% by 2013, while the shares of fossil fuels, metal ores and non-metallic minerals increased by factors of 2.5, 1.9, and 2.4 respectively. It is noteworthy that fossil fuel, the category increasing its share the fastest, is also the category in which India is by far most import-dependent. This has potential implications for India's ongoing energy security.

Comparing Figure 4 to Figure 3 shows that the difference between India's material footprint is somewhat lower than DMI. Interestingly, the gap between the two increased as India became richer, with MF 12% lower than DMI in 1990, and 18% lower by 2013. This is probably driven by an increasing portion of the country's DMI being input to products which are ultimately consumed.
elsewhere, rather than fewer materials of foreign origin being embodied in India's imports for final consumption.

Figure 4 Material footprint of consumption of India by four material categories, 1970–2015, thousand tonnes

Figure 5 reflects the declining relative importance of agriculture in the MF of India, and the rise of construction in particular. Where agriculture accounted for 48% of MF in 1990, by 2013 it constituted 33%, while construction increased from 19% to 30% over the same period. The shares of the other five sectors remained roughly constant over the period, while roughly tripling in absolute terms.
Per capita, the economy of India uses less than half the regional average for materials. The material footprint of consumption would need to almost quadruple to come up to the levels usually associated with a high level of human development.

The material inputs to India’s economy, compared to the average across SWITCH-Asia countries, are still relatively low, with total DMI estimated to be only 4.9 tonnes per capita in 2015, less than one half the SWITCH-Asia average of 11.8 tonnes per capita (see Figure 6). The relative gap between the per capita material footprint\(^3\) of India and the SWITCH-Asia countries as a whole is similar. Most of this disparity came into existence over the study period. In 1970 India’s DMI was over 90% of the (much lower at that time) SWITCH-Asia average, and it remained over 80% of the regional level through until 1990, from which point the divergence accelerated. It is interesting to note that even though economic liberalization commenced from the start of the 1990s, the growth in DMI was relatively slow in the following decade, increasing at a rate of 0.7% p.a. compounding between 1990 and 2000. It was only in the following decade that growth in DMI really accelerated, increasing to 1.7% p.a.

India’s MF, at 4.0 tonnes per capita, is only around 27% of the material footprint per capita generally associated with a high level of human development\(^4\).

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\(^3\) The material footprint is a proxy for the material standard of living in a country, and measures the amount of primary resources attributable to final demand in a country (consumption and capital investment), including those materials indirectly embodied in trade. To illustrate the idea of embodiment as used here, material footprint attributes materials used “upstream” to the nation where final consumption takes place. For example, the iron ore, coal and other inputs used to produce a steel beam which is then exported will mainly be attributed to the nation where that beam is finally used, rather than to the country where the iron ore and coal were mined and/or used to produce the beam.

\(^4\) A "high level of human development” for a country is delineated here as an average life expectancy of 75 years, 10 years of schooling, and a per capita national income of $28,000 in PPP terms. In 2010, the average level of material footprint required to achieve those three goals was approximately 15 tonnes per capita.
Figure 6 Per capita material input and material footprint India and SWITCH-Asia, 1970–2015, tonnes

The economy of India was more efficient at converting materials to GDP than the SWITCH-Asia group average for the entire period 1970 to 2015, and that relative efficiency increased over time. Whereas in 1970 India required 15% less materials per US$ of GDP earned than the regional average, by 2015 this difference had increased to 24%. Figure 7 shows that the changes in material intensity were both major and relatively consistent over the whole period. This improvement in material intensity kept the rate of growth in material inputs to around one half the rate of GDP growth, so that DMI increased at 3.8% p.a. over the full period 1970 to 2015. The trend for (trade) adjusted material intensity is similar to that described for material intensity, both in terms of the ongoing improvements in material intensity, and in being markedly lower than the regional average.

Figure 7 Material intensity of production and consumption in India and SWITCH-Asia, 1970–2015, kg per US$

In Figure 8, the domestic material consumption (DMC) indicator is used to illustrate the long-term waste potential of India. DMC shows territorial consumption of materials, some of which may pass through the economy from input to waste quickly (e.g. metal ores processed to produce saleable
metal), while others may reside as a part of the active economy for years (e.g. construction materials invested in infrastructure). In all cases, that which is consumed territorially will generally need to be sunk back into the local environment as some form of waste at some point, thus the idea of long-term waste potential. Two measures have been used in to illustrate different aspects of the long-term waste potential issue, one which uses a per capita basis, and a second that measures intensity per unit of land area, or spatial intensity. Figure 8 shows that India's long-term waste potential doubled on a per capita basis, and quintupled in spatial intensity, over the study period. While India's DMC per capita remains low, at around 40% of the SWITCH-Asia average, the nation's population density is such that the spatial intensity of waste stocks and flows is over 90% of the regional average. This spatial intensity measure indicates that India is probably already encountering similar environmental pressures to those widespread among the SWITCH-Asia countries. Even relatively moderate ongoing increases on a per capita basis, given India’s ongoing population growth, could see local waste loadings approach levels worse than commonly seen elsewhere in the region today. India is thus one SWITCH-Asia country where maintaining ongoing improvements in resource efficiency is particularly important even in the near term.

Figure 8 Long-term waste potential of India (DMC/ha and DMC/cap), 1970–2015, tonnes per ha and per capita
4 Energy use, energy security, renewable energy and energy efficiency

India’s total energy consumption has increased at a rate comparable to that seen previously for materials, increasing by a factor of 5.5 between 1970 and 2015. On both total primary energy supply (TPES) and Energy Footprint (EF) bases, India's per capita energy consumption is roughly half the SWITCH-Asia average. In Figure 9 we see that India’s per capita energy consumption decreased relative to the regional averages over the study period, even as the absolute levels increased strongly. India’s TPES per capita in 1970 had been three quarters the regional average of 15.6 GJ per capita.

![Figure 9 Per capita TPES and energy footprint of India and SWITCH-Asia, 1970–2015, GJ per capita](image)

In another parallel with materials, Figure 10 shows the underlying shares of the different components of energy supply changing, in a pattern that reflects the ongoing transition from agrarian to industrialized society. Where non-hydro renewables (overwhelmingly biomass) still constituted 60% of TPES in 1970, by the end of the period they constituted less than 28% of TPES, despite more than doubling in absolute terms. It was growth in the use of fossil fuels, mainly coal, followed by petroleum, which supplanted biomass in the nation’s energy systems. Fossil fuels' share increased from 37% to 70% of TPES over the period. Natural gas showed the most rapid increase in relative terms, off a very low initial base of <1% of TPES. These trends in energy supplies reinforce an observation made in the materials section that India's energy supply is increasingly moving away from sources over which the national government had jurisdiction, to sources which are under largely the jurisdiction of foreign governments. The more detailed statistics on fossil fuels contained in IEA data show that while India was 70% self-reliant in coal in

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6 As energy footprint is analogous to material footprint, in that it takes account of the energy embodied in the full production chains of goods and services for local final consumption. This means that EF adds the offshore energy inputs of imported goods and services to local inputs of energy consumption, and subtracts energy inputs to goods and services which are exported.
2013, and 65\% in gas, it is only producing petroleum equivalent to 18\% of TPES in this category (IEA, 2015). Given this, it appears that the area where India’s energy supply is most vulnerable to external shocks is likely to be liquid transport fuels.

![Figure 10 Total primary energy supply of India by energy sources, 1970–2015, in petajoules](image)

Figure 10 shows that India's energy intensity on a TPES basis is marginally higher than the SWITCH-Asia average. Interestingly, India's relative energy efficiency advantage was much greater in 1970, when it used only two thirds as much energy per $ of GDP compared to the regional average. This relative advantage eroded steadily until the early 1990s, by which point it had converged to the SWITCH-Asia average, before re-emerging in the new millennium. Whether this is connected with the economic liberalization of the early 1990s or some other driver is not known, however improvements in resource efficiency have been documented elsewhere in the wake of economic liberalization. Energy intensity based on the EF metric shows India’s intensity at the same level and moving in lockstep with the SWITCH-Asia average over the full period for which EF data was available.
Figure 11 Energy intensity of production and consumption in India and SWITCH-Asia, 1970–2015, MJ per US$


5 Emissions, air pollution and climate change

The statistics used for GHG emissions for India are sourced from the European Commission's EDGAR database. Aggregated GHG territorial emissions and GHG footprints are presented in Figure 12, from which it is evident that India’s GHG emissions per capita have remained well below the SWITCH-Asia average, fluctuating between 38% and 61% for the entire period (the wide bands of fluctuation reflect high annual variation in the regional average, largely as a result of intermittent periods of major forest fires in some southeast Asian countries). India’s low relative GHG emissions are reflected when using a GHG footprint basis as well, although slightly higher than when using territorial emissions. Both India and the region have steadily increasing GHGs per capita on both territorial and footprint metrics.

![Figure 12 Per capita GHG emissions and carbon footprint of India and SWITCH-Asia, 1970–2015, tonnes](image)

In Figure 13 it is clear that growth in India’s GHG emissions has been dominated by rapidly increasing CO₂. This is what we would expect as the energy system shifted from largely carbon neutral biomass-based systems to fossil fuels. There has been a similar strong proportional growth in nitrous oxide, to the extent that by 2010 it already accounted for a higher total CO₂ equivalent than CO₂ itself had back in 1970, however the share actually declined slightly. Emissions of methane more than doubled, while its share of total GHGs halved. The increases in methane are consistent with some expansion in agriculture, but also perhaps changes in agricultural systems,

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7 Reasonable data on both the breakdown of GHGs by gas type, and by economic sector, exist for most countries for the period up 2008. From 2008 on, a detailed sectoral breakout is missing, while data on actual GHG component gases ends in 2012. In assembling the database for the SWITCH-Asia countries, a number of assumptions and scaling options were adopted to derive both the sectoral and component gas compositions of each country’s emissions, while data from 2012 used a simple technique of forecasting based on forecast future growth in GDP and population, and the elasticity of increasing energy use with regard to both population and affluence (GDP/capita). This method appears to provide reasonable results for larger and more stable economies with broad-based and steadily-growing economies, of which India is one. It does not work well for countries where annual GHG emissions can be profoundly affected by forest fires, which show up as major spikes.
reflecting changes in agricultural methods (e.g. increased irrigation), and also an expansion of fossil fuel extraction and the associated fugitive gas emissions.

![Figure 13 Territorial GHG emissions in India by main GHG gases, 1970–2015](image)

In Figure 14 we see that India's GHG emissions on both territorial and footprint metrics have trended down over time, but at a slower rate than the region as a whole. Where India apparently had half the regional average rate of territorial GHG emissions per dollar of GDP in 1970, by the end of the period this had increased to 85%, and the rate of improvement slowed markedly from around 2007. Using the footprint metric, India's GHG emissions had converged to the regional average by 2010.

![Figure 14 Carbon intensity of production and consumption in India, 1970–2015, kg per US$](image)
6 Water and wastewater

It is important to note that data on water extraction and use is the sparsest and least frequently updated basic data of all used for this report.\(^8\)

Figure 15 shows India’s level of water withdrawals per capita to be very close to the SWITCH-Asia average over the full study period, beginning the period 8% lower than the average and ending 12% higher, as India’s per capita value remained relatively static while the regional average decreased marginally. The similarity of trajectories for India and the region are in part explained by India accounting for 40% of the regional total by 2005, making it the largest single contributor. The convergence of India’s water footprint to the regional average is even closer than seen for water withdrawals, and decreased from twice withdrawals in 1990 to just 20% higher by 2010. India’s contributed 35% of the region’s total water footprint, again the largest single component, slightly larger than China’s 34%.

![Figure 15 Per capita water use and water footprint in India and SWITCH-Asia, 1970–2015, kl per capita](image)

India’s water intensity (water extracted per US$ of GDP) decreased by 82% over the full study period. In Figure 16 we see that this rapid improvement is nonetheless not as great as that seen for the SWITCH-Asia group overall, at 93%, so that by the late 1970s India had become less water efficient than the regional average, and by 2015 required approximately twice the regional

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8 The FAO’s Aquastat database has been selected as the standard here. An alternative source would be the World Bank’s WDI statistics. The two have different categorizations, and can diverge quite widely from each other even after aggregation. For most countries there are three or fewer data points available for any full time series. Furthermore, unlike materials, energy and GHGs, it is not reasonable to assume a consistent growth trend over time, as withdrawal levels in any particular year can be much higher or lower according to whether the year the data were acquired was wet or dry. As a result, the values for water extraction recorded for most years have usually been obtained by simply filling with the nearest real data point. Also, water availability is to some extent naturally capped for a country, and not subject to arbitrary, large scale expansion by investing more in extraction infrastructure.
average to generate a dollar of GDP, on both the territorial withdrawals and water footprint metrics.

Figure 16 Water intensity of production and consumption in India and SWITCH-Asia countries, 1970–2015, litres per US$
7 Natural resource use, emissions and human development

In Figure 17 we see India’s HDI improving steadily from 1990 through to 2010. The improvement in HDI over this period averaged 0.7% p.a. compounding. Per capita material footprint increased at a marginally slower rate, 1.1% p.a. over the same period. While EF showed the most rapid improvement of the four indicators charted here, improvements in GHG footprint were much slower, consistent with the shift to greater use of fossil fuels for energy supply. On the face of it, the fact that HDI had the slowest rate of improvement indicates that India is becoming less efficient at achieving increases in human development for a given input of materials and energy, or emission of GHGs. If this interpretation is true, it is cause for concern, however the fact that HDI is a composite indicator cautions against such a simplistic interpretation. Most importantly, some components of the HDI indicator cannot reasonably be expected to respond in a linear fashion to increased inputs, notably lifespan, but also education.

Figure 17 HDI, per capita material and energy use, per capita GHG footprints for India, 1990–2015, indexed (1990=100)
References


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