Oil Shock Vulnerabilities & Impacts: India Case Study

Prepared for the United Kingdom Department for International Development

by

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Source: United Nations (2012)

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Abbreviations

AAI	Airports Authority of India
ASEAN	Association of Southeast Asian Nations
BPCL	Bharat Petroleum Corporation Limited
bpk	billion passenger kilometres
bpd	barrels per day
CAD	Current Account Deficit
CNG	Compressed Natural Gas
DES	Directorate of Economics and Statistics
DGFT	Directorate General of Foreign Trade
EIA	Energy Information Administration
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
GQ	Golden Quadrilateral Highway Project
GVA	Gross Value Added
HPCL	Hindustan Petroleum Corporation Limited
IEA	International Energy Agency
IMF	International Monetary Fund
IPA	Indian Ports Authority
JVC	Joint Venture Company
LPG	Liquefied Petroleum Gas
MJ	megajoules
MMTOE	million tonnes of oil equivalent
MOF	Ministry of Finance
MORTH	Ministry of Road Transport and Highways
MOS	Ministry of Shipping
MPNG	Ministry of Petroleum and Natural Gas
MRTS	Mass Rapid Transit Systems
MT	million tonnes
NELP	New Exploration License Policy
NFSM	National Food Security Mission
NHAI	National Highways Authority of India
NPOI	National Portal of India
NRAA	National Rain-fed Area Authority
OIFC	Overseas Indian Facilitation Centre
ONGC	Oil and Natural Gas Corporation
OVL	Oil and Natural Gas Corporation Videsh Limited
RPL	Reliance Petroleum Limited
TFEC	Total Final Energy Consumption
TJ	terrajoules
TPES	Total Primary Energy Supply
WPI	Wholesale Price Index

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Introduction

This report presents an Indian country case study of oil dependencies and vulnerabilities to oil price and supply shocks, and forms part of a broader study commissioned by the United Kingdom Department for International Development titled "Oil Shock Mitigation Strategies for Developing Countries". India had a Gross Domestic Product (GDP) per capita of $1 420 in 2011 (IMF, 2012), which places it in the lower-middle income country category of the World Bank. Additional indicators for development measured by the World Bank, such as primary school enrolment, life expectancy at birth and carbon dioxide emissions also demonstrate that India is representative of the lower-middle income country category. However, India represents a unique case within this income category in that the country exhibited consistent economic growth until 2011 despite a slowing global economy. In addition, India has the second largest population in the world and according to the World Bank (2012) the third largest economy when measured in purchasing power parity terms. India is increasingly dependent on imports for its growing energy needs. In 2010, India was relying on imported oil for more than 70% of total oil consumption (EIA, 2011).

The population of the country as per the provisional figures of Census of India (2011) is 1210.19 million (ORGI, 2011). With more than 1.2 billion people, India is the world's largest democracy. The country has emerged as a global economic player over the last decade. Economic growth has translated into a substantial decline in poverty. According to official Government of India estimates, poverty declined from 37.2% in 2004-05 to 29.8% in 2009-10. In 2009, India was the fourth largest energy consumer in the world, after USA, China and Russia (EIA, 2011), and the third largest crude oil consumer in the Asia-Pacific region after China and Japan (MOSPI, 2012).

The case study is organised according to five subsystems of the socio-economic system, namely: energy; transport; agriculture; macro-economy; and society. Each of the first four major sections includes a brief overview of the subsystem, an analysis of its oil dependency, and a discussion of the likely impacts of oil shocks under business-as-usual policy environments. Section 5 analyses important characteristics of contemporary Indian society that increase its social vulnerabilities to oil shocks. The concluding section provides a summary of key strengths, vulnerabilities and likely impacts of oil shocks in each of the five subsystems.

1. Energy

This section presents an overview of the energy system and the role of oil products in India. It begins with a summary of primary sources of energy supply, energy carriers and final consumption (demand) by major sectors, i.e. the national energy balance. The focus is then narrowed to the supply and demand for oil and petroleum products. Oil supply is discussed in terms of sources (imports and domestic production), refining and stockpiles. Demand for petroleum products is analysed according to product type, geographical region and economic sector. The final subsection briefly considers the likely impacts of oil shocks on the energy system.

1.1 Overview of the energy system

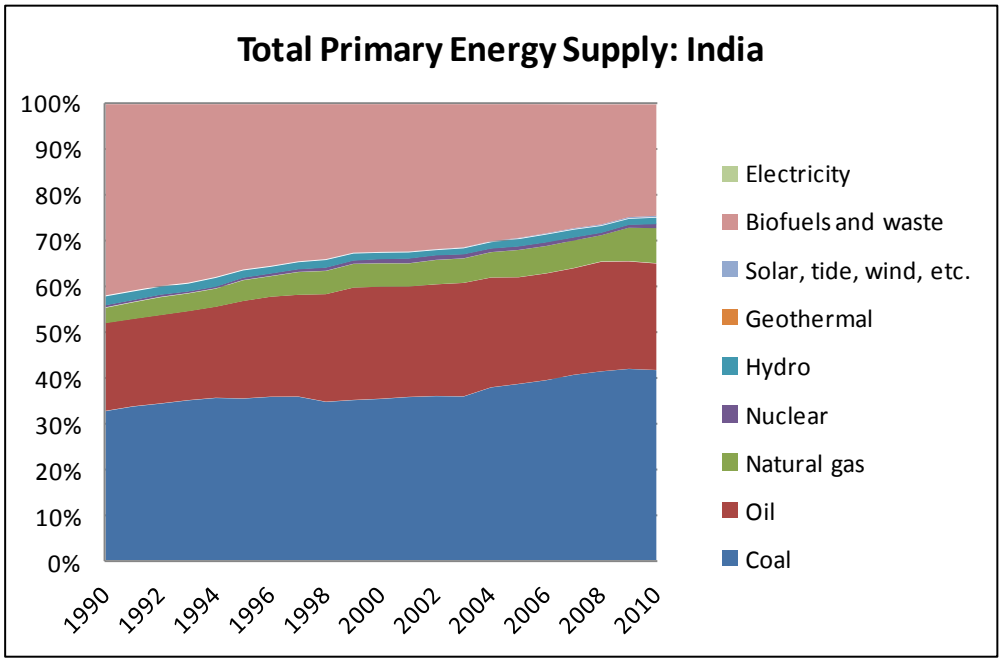
The role of oil in India's energy system needs to be placed in the context of overall energy supply and demand balances, i.e. alongside other sources of primary energy and within the final energy consumption mix. The next few sections are based on two major components of the energy balance statistics: the Total Primary Energy Supply (TPES) and the Total Final Energy Consumption (TFEC) of energy carriers.

Primary energy supply

India's energy mix comprises of both non-renewable sources (coal, lignite, petroleum, natural gas and nuclear power) and renewable energy sources (wind, solar, small hydro, biomass, cogeneration bagasse, etc.). Figure 1 displays the evolution of India's primary energy supply mix between 1990 and 2010.

Since 1996 coal has been the dominant fuel for primary energy, growing from 32% of TPES in 1990 to more than 41% in 2010. Oil's share also rose marginally to 25% in 2003 from 19% in 1990, and has remained consistently above 23% since 2003. The share of gas has more than doubled over the two decades, starting at just over 3% in 1990 and contributing 7.6% in 2010. The combined shares of nuclear, hydro and renewables (solar, wind, etc.) have never exceeded 3%, while the share of combustible renewables and waste (e.g. wood, used for cooking and heating) has declined significantly from 42% in 1990 to 24.6% in 2010. While the total primary energy requirement registered an average annual growth rate of 4% between 1990-91 and 2009-10, the primary commercial energy requirement registered an average annual growth rate of 5.68% during the same period.

Figure 1: Shares of total primary energy supply by source, 1990-2010



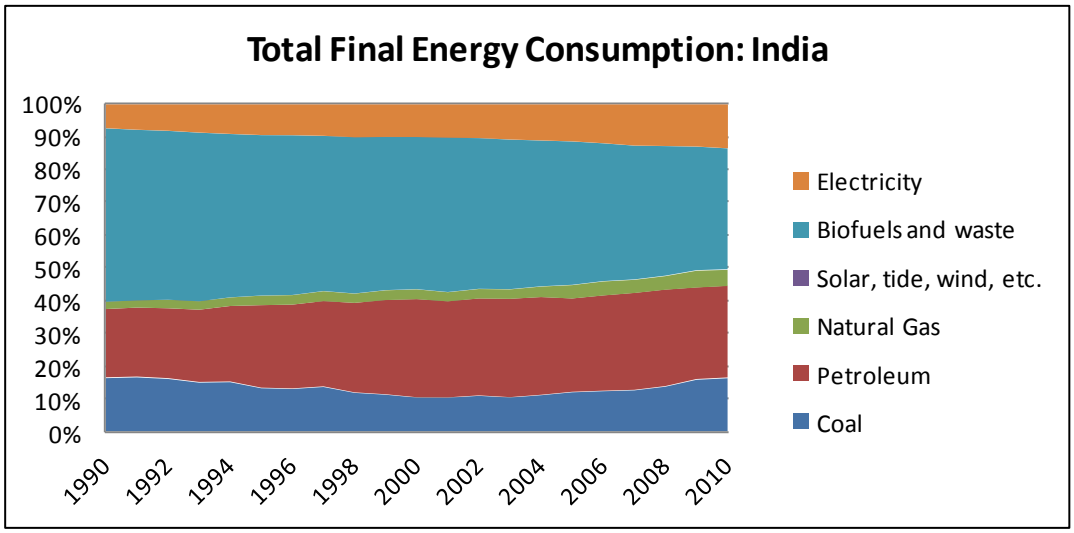
Source: IEA (2012)

Final energy consumption

Primary energy sources (e.g. oil) are converted into energy carriers (e.g. petroleum fuels), which are then consumed by end users. Petroleum products and combustible materials have contributed significant shares of final energy, while the share of electricity has nearly doubled during 1990-2010 (see Figure 2 below). Over the period, the direct use of coal has remained above 16%, after recovering from a decrease to almost 10% in 2000-2001. By 2010, petroleum accounted for over 28% of final energy consumption, a marginal increase from 20.9% in 1990. In 2010, natural gas accounted for a five percent share, which is expected to grow with the discovery of new gas deposits (IEA, 2012).

Coal and petroleum account for a large share (about 44%) of India's final energy consumption. Combustible renewables and waste constitute about one third of Indian energy use. The large share of non-commercial energy sources include traditional fuels like wood, cow dung and crop residues, a large proportion of which is used by predominantly rural households for their thermal and cooking needs (Planning Commission, 2007a). This is indicative of India's lower middle income country status.

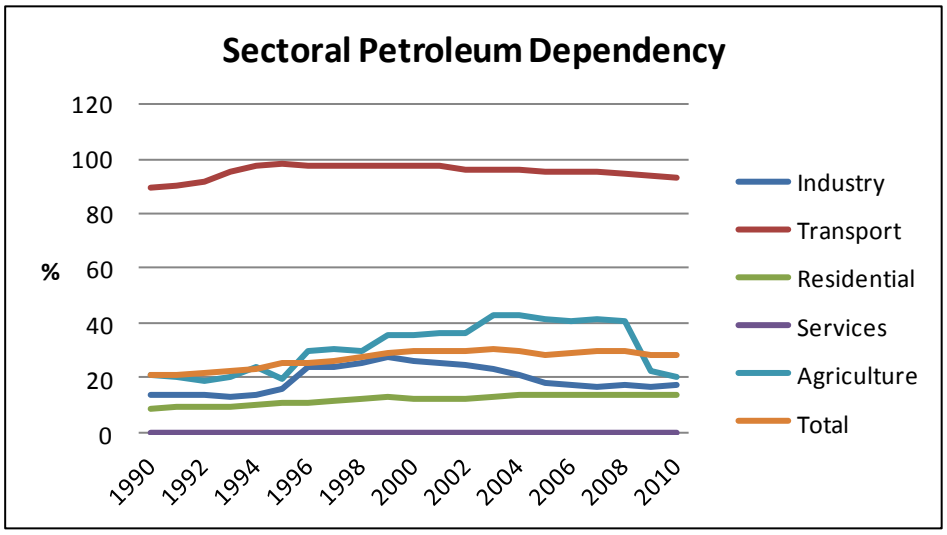
Figure 2: Shares of total final energy consumption by energy type, 1990-2010



Source: IEA (2012)

The shares of petroleum products in final energy consumption by sector and for the economy as a whole between 1990 and 2010 are displayed in Figure 3. In almost all sectors, the share of total final energy consumption accounted for by petroleum products has been fairly stable, and for the country as a whole has ranged between 20% and 29%. The transport sector is by far the most heavily reliant on petroleum products, with consumption remaining consistently above 90%. Petroleum dependency in agriculture peaked in 2003 at 43% but has reduced significantly since then to 20%. This may be the result of changes in statistical accounting methods since 2008.

Figure 3: Share of petroleum products in final energy consumption by sector, 1990-2010



Source: Author's calculations based on IEA (2012)

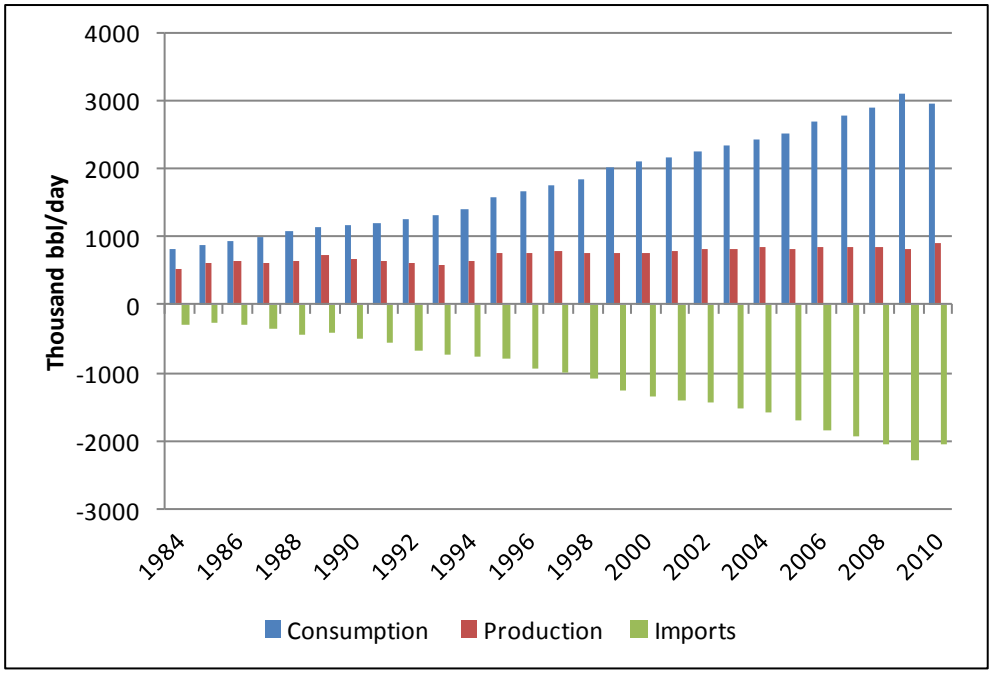
1.2 Oil dependence of the energy system

Supply of oil

In India, more than 70% of crude oil consumption and part of the petroleum products demand is met through imports (MOSPI, 2012). India imported more than 3.2 million barrels per day (bpd) of crude oil, or 163.59 million tonnes (MT), during 2010-11 (MOSPI, 2012). India produced roughly 950 thousand bpd of total liquids in 2010, of which 750 thousand bpd was crude oil (or 37.7 MT) (EIA, 2011; MOSPI, 2012). During 2011-12, production of crude oil is estimated at 38.19 MT, which is about 1.33 per cent higher than during 2010-11 (MOF, 2012). India's crude oil reserves stood at 5.7 billion barrels as of January 2011, the second largest in the region after China (EIA, 2011).

Error! Reference source not found.4 displays India's total annual production, consumption and imports of oil (crude oil plus refined petroleum products) from 1984 to 2010. Domestic production has remained below 1 million barrels per day (bpd) during the period, while consumption has more than trebled. Production levels barely cater to a quarter of the petroleum products demand and the remaining oil requirements are met by imported crude (Planning Commission, 2007a). Despite recent government efforts to deregulate the hydrocarbons industry, state owned enterprises dominate the Indian oil sector, with the Oil and Natural Gas Corporation (ONGC) accounting for nearly three-quarters of oil production in the country (EIA, 2011).

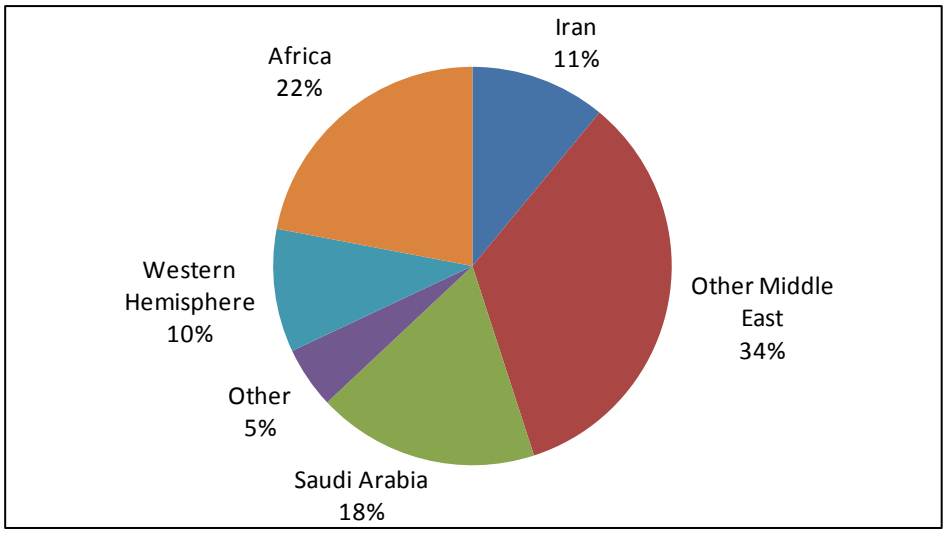
Figure 4: Indian oil production and consumption, 1984-2010



Source: EIA (2012)

In 2010, the majority of India's crude oil imports came from the Middle East, with Saudi Arabia (18%) and Iran (11%) providing the largest individual shares (see Figure 5) (EIA, 2011). The share of India's oil imports supplied by Iran has decreased in recent years (down from 16% in 2008), largely due to US sanctions to deter foreign investment in Iran (EIA, 2011). In order to continue undisrupted crude oil supply from Iran, India will pay for 45% of its transactions in rupee terms, as per recent trade negotiations, which Iran can use to buy commodities and products from India (Mishra, 2012).

Figure 5: India's sources of crude oil imports, 2010



Source: EIA (2011)

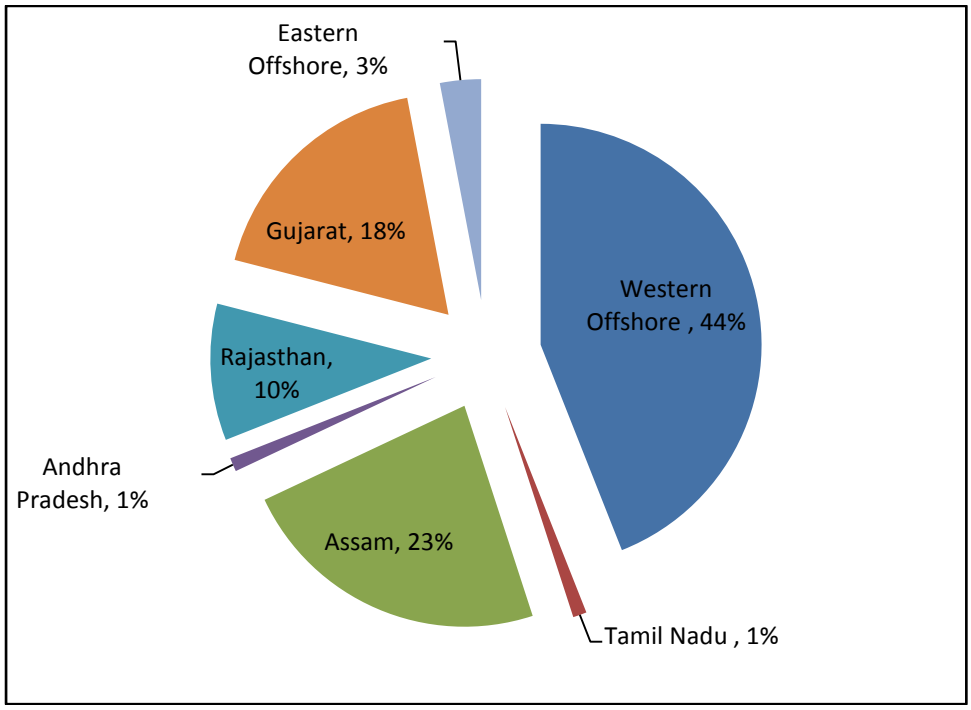
India has the fifth largest **refining capacity** in the world of roughly 4 million bpd in 2011 (EIA, 2011). The country was utilising 20 facilities as of 31 March, 2011 (MOSPI, 2012). The majority of the refineries are in the public sector and are owned and operated by state owned enterprises such as IOC (Indian Oil Corporation), operating 8 refineries, BPCL (Bharat Petroleum Corporation Limited) and HPCL (Hindustan Petroleum Corporation Limited). Private sector companies include Essar Oil and Reliance Industries' Reliance Petroleum Limited (RPL) (MOSPI, 2012). RPL's Jamnagar complex is the largest oil refining complex in the world, with a total capacity of 1.24 million bpd (EIA, 2011). Capacity utilisation of the refineries was 110% during 2010-11 (MOSPI, 2012). The IOC controls a lion's share (nearly 75%) of the domestic oil transportation network (EIA, 2011). Public sector refineries are located at Guwahati, Barauni, Koyali, Haldia, Mathura, Digboi, Panipat, Vishakhapatnam, Chennai, Nagapatinam, Kochi, Bongaigaon, Numaligarh, Mangalore, Tatipaka, and two refineries in Mumbai; the private sector refineries built by RPL and Essar Oil are in Jamnagar and Vadinar, respectively (MOSPI, 2012).

India refines in excess of its needs (3.2 million bpd in 2011), and is a net exporter of refined fuels (EIA, 2011). Further investment in the Indian refining sector is linked to expectations of greater demand for petroleum products in the region, and the Indian government's promotion of the country as a competitive refining destination in Asia (EIA, 2011). The Asia-Pacific region is expected to continue to be the most important driver of global oil demand (ONGC, 2012).

The estimated **reserves of crude oil** in India stood at 5.7 billion barrels, indicating a 2% decrease during 2010-2011 for the country as a whole (MOSPI, 2012). Geographical distribution of crude oil among regions and states (or provinces) (Figure 6) indicates that the largest share of reserves are in the Western Offshore (which includes Bombay High offshore, Rajasthan and JVC[1]) (43%), followed by Assam at 22% (MOSPI, 2012). Additionally, an increase of estimated crude oil reserves by 33% was observed in Andhra Pradesh followed by Tamil Nadu (8%).

[1] JVC stands for Joint Venture Company which was the status of the Oil India Limited (OIL) from 27th July 1961, as a result of Government of India (GoI) partnering equally with BOC (Burmah Oil Company). BOC's shares were bought over by GoI in 1981, making OIL a wholly Indian government owned enterprise.

Figure 6: Estimated reserves of crude oil in India as on 31 March 2011



Source: Ministry of Petroleum and Natural Gas

Indian government policies target an increase in **domestic exploration and production** activities in the oil and gas sector (EIA, 2011). The Ministry of Petroleum and Natural Gas created the New Exploration License Policy (NELP) in 2000, in order to attract international companies, which for the first time were allowed to hold 100 percent equity ownership in oil and natural gas projects (EIA, 2011). However, the majority of oil fields remain under the ownership and management of Indian public or private companies. For instance, India's largest oil field, the offshore Mumbai High Field, located north-west of Mumbai, is operated by ONGC (MOSPI, 2012).

Despite government initiatives to attract further investment into domestic exploration, Indian oil production is expected to grow at an average annual rate of less than one percent through 2035 (EIA, 2011). As a result, Indian national oil corporations are increasingly exploring the potential of **overseas exploration and production** projects. ONGC Videsh Limited (OVL), the overseas investment arm of ONGC is the most active state owned enterprise, with oil and natural gas acquisitions in 15 countries including Russia, Venezuela, Columbia, Iran, Burma and Brazil (EIA, 2011; ONGC, 2012). The company was producing approximately 135 thousand bpd in 2010-11, with slightly reduced levels of 125 thousand bpd in 2011-12 (ONGC, 2012). Production was adversely affected by the geo-political situation in Syria, Sudan and South Sudan (ONGC, 2012). OVL is expected to expand production levels to 441 thousand bpd (or 20MMTOE per annum) by 2018 and 1204 thousand bpd (or 60MMTOE per annum) by 2030, in order to contribute at least 46% of ONGC production targets for the medium term (ONGC, 2012).

Buying equity stakes in foreign oil and gas blocks by the Indian government is driven by the need to become energy secure. However, international oil market analysts argue that overseas investments are unlikely to shelter countries from oil market volatility (Sinha and Dadwal, 2005).

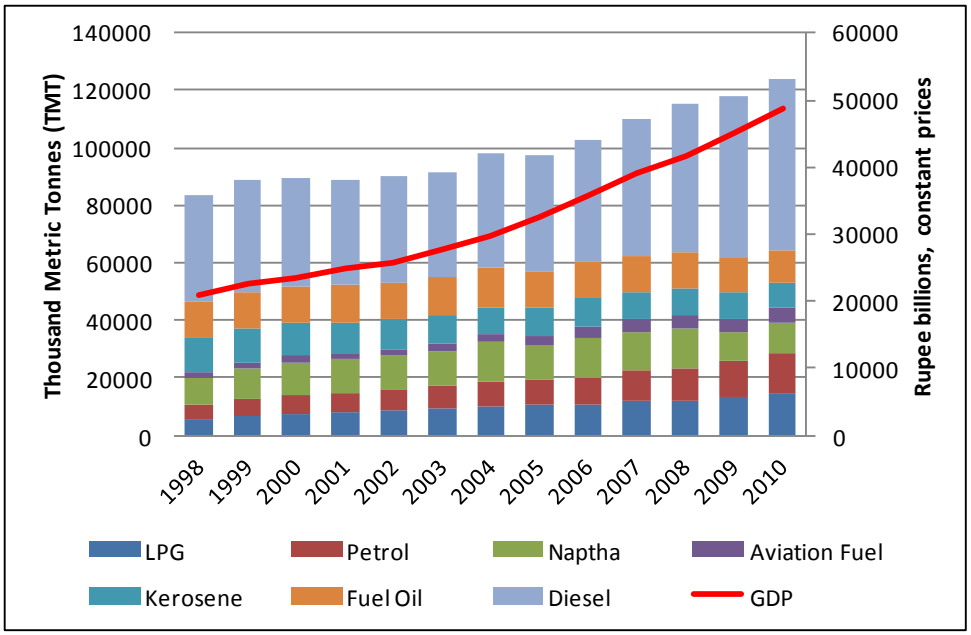
India is constructing a **strategic petroleum reserve** at three underground storage facilities located near refining centres Visakhapatnam, Mangalore, and Padur. Visakhapatnam facility is scheduled to be completed by the end of 2013 (EIA, 2011). However, there has been a delay in the building of the

reserves due to unexpected geological factors (Dutta, 2012). The reserves will hold close to 40 million barrels of oil, which translates into about ten days' of supply on a refinery-throughput basis (EIA, 2011). India plans to add a further 92 million barrels of strategic oil reserve at Padur and 3 additional locations over the next 4 to 5 years (Dutta, 2012). This will provide a very important buffer in the event of future oil supply shocks.

Demand for oil

This subsection presents historical data describing the consumption of petroleum products in total, disaggregated by product type and sector, and a commentary on per capita consumption. Total annual sales of petroleum products grew in line with the economy (real GDP growth) in the period 1998 to 2010 (see Figure 7). The total sales of petroleum products in India have increased to 141.751 MMT in 2010 as compared to 90.162 MMT in 1998 (MPNG, 2011). There is substantial growth in the sales of aviation fuel, LPG and petrol (2.5 times), while kerosene has consistently shown a negative growth in terms of demand since 1998-99, since its use by urban households has been partially replaced by electricity. The sales of fuel oil have decreased marginally, while the sales of diesel have increased by almost 60% since 1998-99. The relatively small share of petrol in total petroleum product usage is explained by the low penetration of private passenger vehicles amongst the Indian population.

Figure 7: Annual total petroleum product sales and GDP, 1998-2010

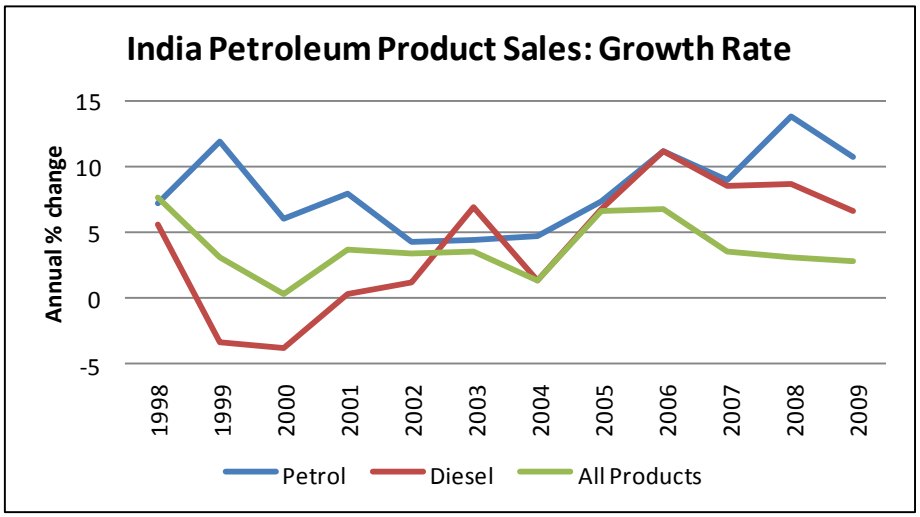


Source: MPNG (2011) and World Bank (2012)

The average growth rate for sales of all liquid petroleum fuels was 3.9% for the period 1998 to 2009 (see Figure 8). In that period the average annual growth rate for diesel was 4.1%, and for petrol, 8.2%. Growth rates of petroleum product sales declined gradually after 2008 as a result of sharply rising fuel prices (crude oil traded at $97 per barrel on average for the year (BP, 2012)). The gradual decline can be attributed to India's petroleum pricing mechanism which is notionally benchmarked on international oil prices, but the government subsidizes domestic prices of refined products (EIA, 2011). Losses from selling products below world market prices are borne by the national government, costing more than $20 billion a year (EIA, 2011). Subsidy support is targeted mainly towards the country's poor who consume kerosene and LPG. The rationale for subsidizing diesel was that it is consumed primarily in freight and agriculture. The government announced deregulation of petrol prices in 2010, and price for kerosene, diesel and LPG increased by between 9 and 20 percent

(EIA, 2011). Petrol is regulated despite notification. However, regulatory efforts are underway to benchmark both petrol and diesel.

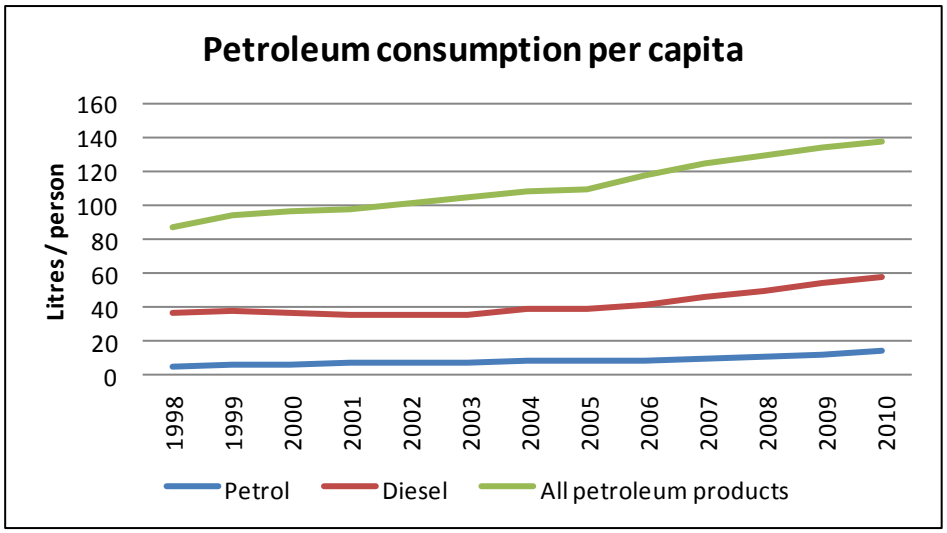
Figure 8: Annual growth in petroleum product sales, 1998-2009



Source: Own calculations based on MPNG (2011)

Figure 9 shows the **per capita consumption** of petroleum products for the period 1998 to 2010. There is a gradually increasing trend till 2004, after which the rate of increase is higher. The newly appointed Petroleum and Natural Gas Minister M. Veerappa Moily is determined to triple the current oil consumption levels of 1.2 barrels per person per year to 6 barrels per person per year, bringing it closer to the world average of 14 barrels (The Hindu, 2012). Given India's population of 1.2 billion people, meeting such energy equity goals would imply a national rate of oil consumption of nearly 20 million bpd, or more than current U.S. consumption. Given the constraints on oil supplies discussed in the main report, this aspiration does not seem likely to be fulfilled.

Figure 9: Petroleum consumption per capita in India, 1998-2010



Source: Own calculations based on MPNG (2011) and ORGI (2011)

1.3 Likely impact of oil shocks on the energy system

Oil's share in TPES (23%) and over 28% of final energy consumption in 2010, of which more than 70% is imported, threatens the country's growth through international oil price and supply shocks. Although past trends show that oil demand in India has been price inelastic, further increases in oil prices may be expected at some point to begin to gradually dampen demand and result in less petroleum energy being consumed in the country, especially in the longer term. The prices of other energy sources, especially those that are to a limited extent substitutable for oil – such as coal and gas – are likely to rise along with the oil price. These price rises will in turn put upward pressure on the price of electricity, since coal is the feedstock for about 70% of national power generation. According to Coal India Ltd., transportation of coal by railways to coal-fired power stations currently suffers from severe infrastructural bottlenecks, while mining regions also suffer from poor road connectivity (Chaturvedi, 2012). The costs of upgrading infrastructure for increased production of coal-based thermal power will increase to some extent as a result of rising fuel costs. Buying or manufacturing, transporting and installing renewable energy infrastructure, including wind turbines and solar panels, will also increase due to higher petroleum fuel costs. The rising cost of alternative energy sources illustrates their dependence on an economic infrastructure that is itself dependent on oil. Thus there will be added upward pressure on electricity prices. However, the rising cost of fossil fuel energy will make renewable energy (RE) sources relatively more competitive and is likely to stimulate investment in this sector. Increased production of RE technologies could deliver economies of scale and learning, and hence reduce their prices, setting off a positive feedback loop. Thus over the longer term, one can expect a process of (partial) substitution of renewable energy for oil and coal.

Acute physical shortages of oil products, which could arise from time to time owing to global supply interruptions, could have more serious consequences than gradually rising (or volatile) energy costs. Strategic oil reserves are meant to alleviate concern over security of oil supplies in emergency situations such as conflict, natural calamities or a sudden spike in the international price of oil (Dutta, 2012). India does not have very large strategic oil reserves which makes the economy highly vulnerable to oil supply disruptions. Significantly, a sudden interruption of liquid fuel supplies could worsen the flow of coal to power stations, since more than 70% of railway freight (the preferred form of coal transportation in the country) runs on diesel, and further disrupt electricity generation. As it is, India suffers from a severe shortage of electricity generation capacity, linked to coal shortages (EIA, 2011).

In addition to the above potential impacts of oil price shocks, the current governance of the energy sector in the Indian institutional system poses a significant challenge in that multiple decision-making structures are in existence, with the potential to diffuse policies to deal with high vulnerability to oil price and supply shocks. The Government of India has a Ministry of Power, a Ministry of Coal, a Ministry for Petroleum and Natural Gas and a Ministry of New and Renewable Energy. Effective coordination among these various ministries will be essential to deal with energy security threats in the medium to long term, unless a single Ministry of Energy is institutionalised.

2. Transport

Effective transport systems are essential for the conduct of local, regional and international commerce and trade, and mobility is an important determinant of human welfare. This section begins with an overview of India's transport system. It then details the oil dependence of the transport system, before identifying key strengths and vulnerabilities in relation to oil price and supply shocks and likely impacts of such shocks.

2.1 Overview of the transport system

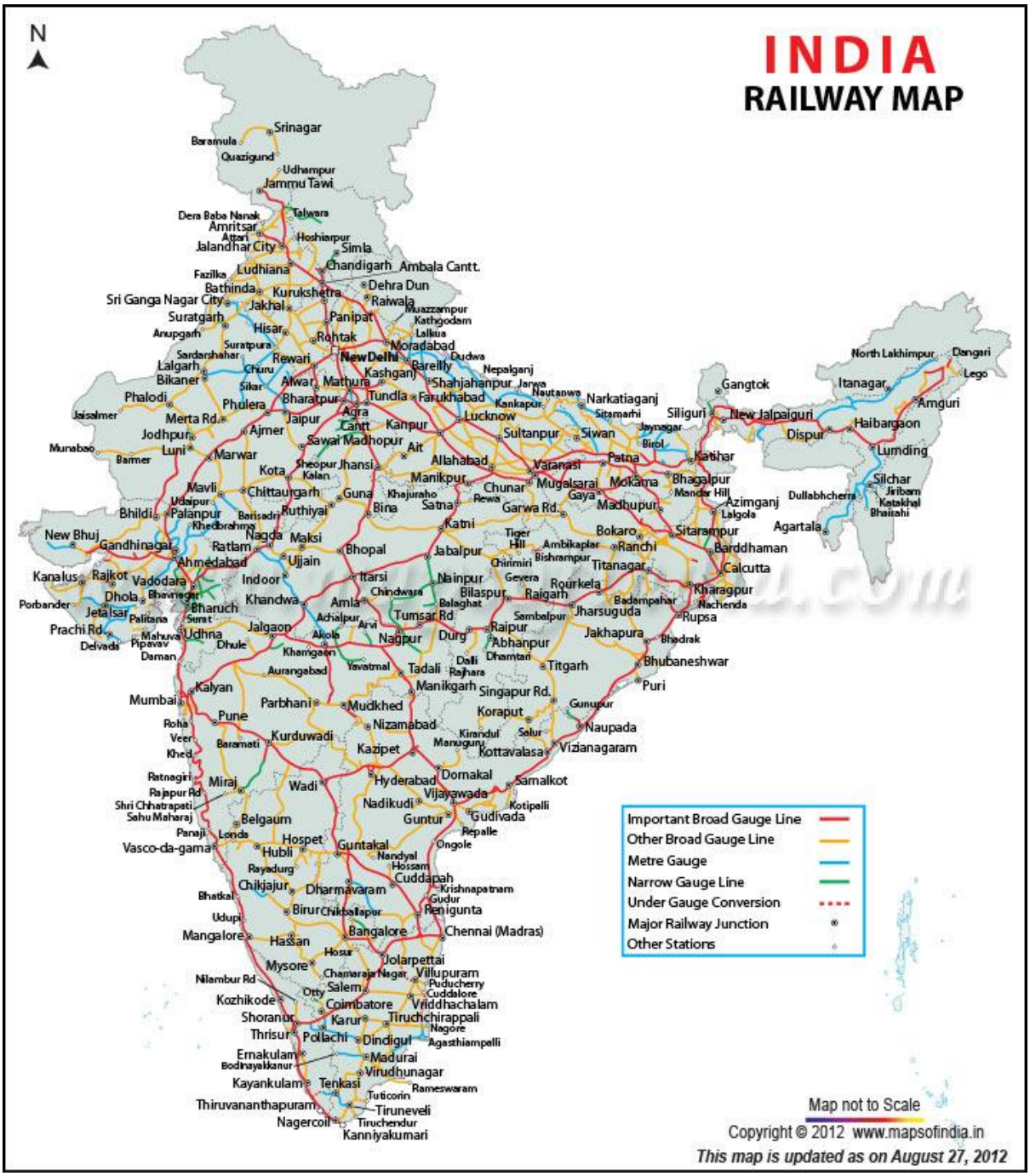
The transport system is characterised by infrastructure, passenger travel and freight movement. Each of these facets is considered in turn, according to various transport modes, namely road, rail, air and sea.

Transport infrastructure

India's transport system, catering to a population of more than 1 billion people, is large and diverse. In 2010, transport, storage and communication contributed about 7.7 percent to the nation's GDP at current prices (MOF, 2012). The total length of classified road networks in India, which ranks as the second largest in the world, as at the end March 2011 is placed at 4.7 million km of which only 53.8% is surfaced (MORTH, 2012a). India's road network consists of national highways, state highways, district roads and rural roads. Crucial to the growing economy, the National Highway network has more than doubled in its coverage over two decades: from 33, 650 km in 1991 to 76,818 km in 2012, and carries 40% of road traffic, but is only 2% of total road length (MORTH, 2012a). Of the national highways, 24% are single or intermediate lane, more than 50% are double lane and 24% are four, six or eight lane. A major initiative for capacity enhancement of the National Highways is the Golden Quadrilateral (GQ) Highway Project connecting India's four largest metros: Delhi, Mumbai, Chennai and Calcutta, and the North-South and East-West corridors. GQ was announced as completed in January 2012. Despite a very high road density of 1.42 km of road length per sq km of land (as compared to USA's 0.67 km/sq km), roads are highly congested and require extensive maintenance (MORTH, 2012a), in both urban and rural areas.

Indian Railways is the largest rail network in Asia with 115, 000 kilometres of track over 64, 460 route kilometres. The network runs around 11,000 trains every day and transports nearly 21 million passengers and 2.5 million tonnes of freight daily (MOR, 2011). With more than 9,200 locomotives and 7,133 stations countrywide, India's railway network (see Figure 10) is justifiably called the 'life-line to the nation' (MOR, 2011). Strategic investments are underway to strengthen the Golden Quadrilateral network by running higher speed passenger and freight trains, strengthen rail connectivity to ports, and incorporate rail infrastructure as part of multimodal corridors to the hinterland (MOR, 2011).

Figure 10: India's railway network



Source: Maps of India (2012)

In terms of existing and potential infrastructure India has 449 airports/airstrips, of which the Airports Authority of India (AAI) manages a total of 125 (11 international airports, 8 customs (potential international) airports, 81 domestic airports and 28 civil enclaves in defence airfields) (AAI, 2012). AAI is in the process of on-going upgrades of the international airports in India, in accordance with global standards. India has a coastline of 7,517 kilometres, on which there are 13 major ports and 187 minor ports, handling over 90% of the country's international trade (IPA, 2012). Amongst the 185 non-major ports, only around 61 are functional (RITES, 2009). The minor ports are under the jurisdiction of respective State governments and handled roughly 35% of total maritime traffic during 2010-11, while the major ports handled 569.91 million tonnes (IPA, 2012).

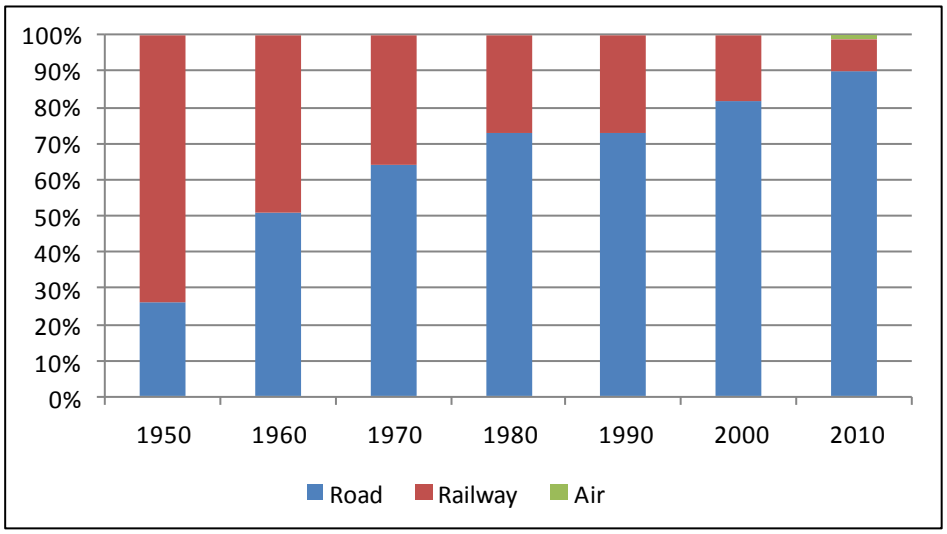
According to the Planning Commission of India, the capacity of Indian ports needs to nearly double over the next five years in order to handle the fast growing cargo traffic (OIFC, 2012). Since the formation of the Indian Waterways Authority of India, three waterways on the rivers Ganga, Brahmputra and West Coast Canal have been declared as National Waterways (RITES, 2009).

Passenger travel

Passenger mobility has increased tremendously in India, nearly ten-fold, from 1,060 billion passenger-kilometres (BPK) in 1990 to 10,230 in 2010 (Ghate and Sundar, 2011) (Figure 11). Linked to an 88% growth in population from 1970-2000, motorised mobility by road increased by 888% (Singh, 2006b). Liberalisation of the Indian economy in the late 1980s, diversity in the automobile market and the availability of low-interest finance encouraged private motor vehicle ownership, which has increased by roughly 10% from 2001 to 2011 (MORTH, 2012a). Increases in household incomes, increases in commercial and industrial activities, availability of motorized transport, and improvement in road transport infrastructure have all contributed to the trend (Singh, 2006a).

The road sector has emerged as the most dominant means of passenger travel, accounting for 85% of the total passenger movement by rail and roads put together (MORTH, 2012a). There is a sharp decline in the share of railways in the inter-modal split, linked to a slower rate of rail infrastructure supply of 385 km of running track per year between 1970 and 2010, compared to 3620 km of road per year (Ghate and Sundar, 2011). Air traffic in India has increased at an average annual rate of 18.5% in the last seven years (MOF, 2012). Domestic passenger traffic handled at Indian airports reached 108.1 million during 2011 from a level of 90.5 million in the previous year (MOF, 2012). International passenger traffic, at 33.6 million passengers, grew by 7.7% during 2011 (MOF, 2012). Water-based transportation accounted for only 0.6% of Indian passenger transport in 1991 and 0.3% in 2001 (Zhou and McNeil, 2009). Between 1990 and 2000, reliance on road transport grew the fastest at 8.3%, followed by air at 5.8% and rail by 4.2%, while demand for water has grown at a slower pace of only 1.7% (Zhou and McNeil, 2009).

Figure 11: Inter-modal distribution in passenger mobility (1950-2010)



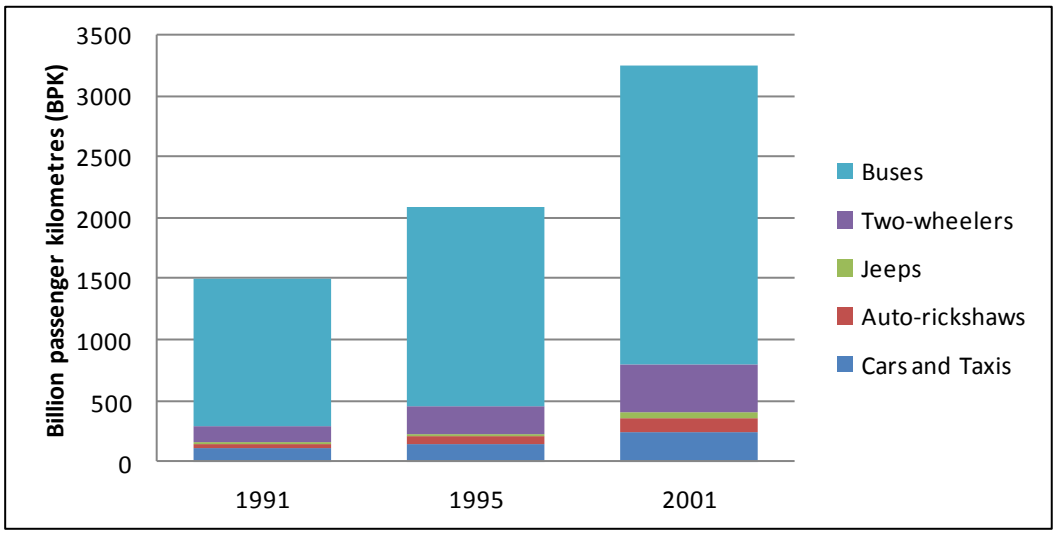
Source: Ghate and Sundar (2011)

As of 31 March 2011, there were approximately 142 million self-propelled registered vehicles on India's roads, including 102 million two-wheelers (72%), 19 million cars, jeeps and taxis (14%), 1.6 million buses (including omni buses) (1%), 7 million goods vehicles (5%) and 12 million other vehicles such as auto-rickshaws (8%) (MORTH, 2012b). Motorised vehicle ownership stands at 30% of the urban population, as compared to 8% of rural population (ORGI, 2011). Passenger car ownership level in India is low at 13 per 1000 persons, compared to 400 plus for higher income countries (MORTH, 2012b).

Figure 12 shows passenger transportation mobility by vehicle type. The share of passenger kilometres for buses declined from 80% to 75% over 1990-2010, cars and jeeps increased from 6.7 to 7.7%, and two-wheelers increased from 9% to 12%. Auto-rickshaws increased from 2.4% to 3.4% while jeeps had a minimal increase of 0.2% over the period. Non-motorised transport in the form of bicycles and especially cycle rickshaws remain a prominent feature of Indian cities. The National Capital Region has 600,000 cycle rickshaws, often as feeders to public transport (UN-HABITAT, 2011). Amongst motorised road transport modes assuming maximum loading, diesel fuelled buses are the most energy efficient, followed by diesel cars, (single-occupant) scooters and motorcycles, and petrol cars (Wakeford, 2012).

The top 3 Indian cities: Delhi, Mumbai and Kolkata, have rail-based Mass Rapid Transit Systems (MRTS) in operation or in planning. The Planning Commission recommends financing over the 12th Five Year Plan for MRTS @ 10km/million population to be built (or extended) in mega cities: Chennai, Bangalore, Hyderabad, Pune, Surat and Ahmedabad (population of more than 4 million) (Planning Commission, 2012).

Figure 12: Road passenger transportation mobility by vehicle type (1990-2010)

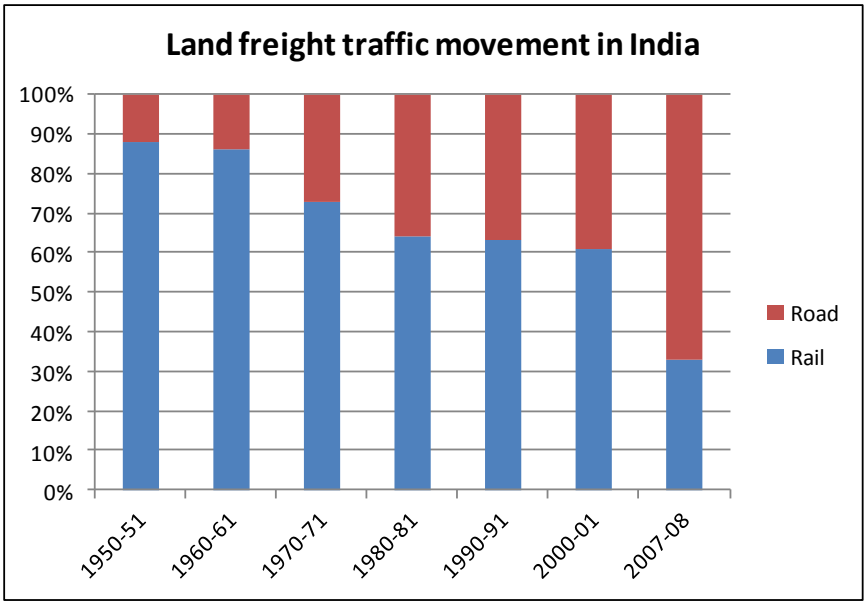


Source: Zhou and McNeil (2009)

Freight movement

Figure 13 shows the relative share of rail and road in India's land-based freight transport sector from 1950 to 2008. The relative share of rail declined from 86.2% in 1960-61 to 63.5% in 1980-81 while the share of road increased from 13.8% to 36.5% over the same period (Pangotra and Shukla, 2012). As a result of policy decisions, railways lost a majority of piecemeal cargo to trucks during the 1980s and since the 1990s, the share of rail has steadily declined (RITES, 2009). Although freight traffic by coastal shipping has grown over ten times in the twenty years since 1986, its percentage share in total freight traffic remained just over 2.3% in 2007-08 (RITES, 2009).

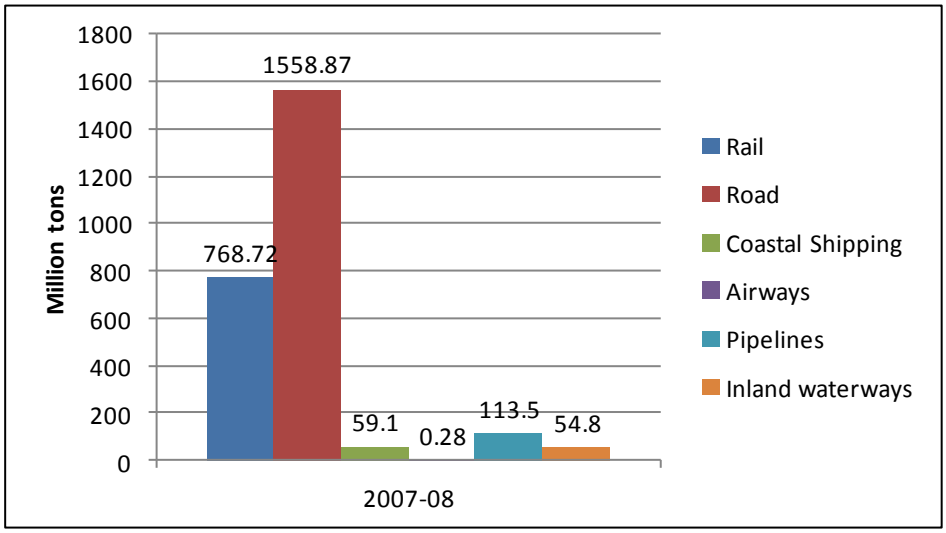
Figure 13: Land freight transport in India, 1950-2008



Source: Pangotra and Shukla (2012)

Figure 14 shows total Indian freight traffic by mode during 2007-08. In the total originating freight traffic of 2555.35 million tonnes, handled by all six modes, the shares of railways and road transport were around 30% and 61%, respectively. The remaining 9% was handled by coastal shipping (2.3%) and inland waterways (2.2%); a small percentage by airways (0.01% at 0.75 MT); and a growing percentage by pipelines (4.4%) for the transport of petroleum products and natural gas (RITES, 2009; Pangotra and Shukla, 2012). By 2010, Indian roads carried 63.9% of freight traffic (MORTH, 2012a). According to the Planning Commission, a substantial increase in logistics and transportation infrastructure is required during the 12th five year plan (2012-2017) to address 'planned new power capacity addition, increase in coal imports, and expected growth of manufacturing output' (Pangotra and Shukla, 2012:17). Transport policy should direct increases in rail-based transportation infrastructure to support the projected increase in freight demand, away from freight traffic by road.

Figure 14: Freight volume in million tonnes (2007-08)



Source: RITES (2009)

2.2 Oil dependence of the transport system

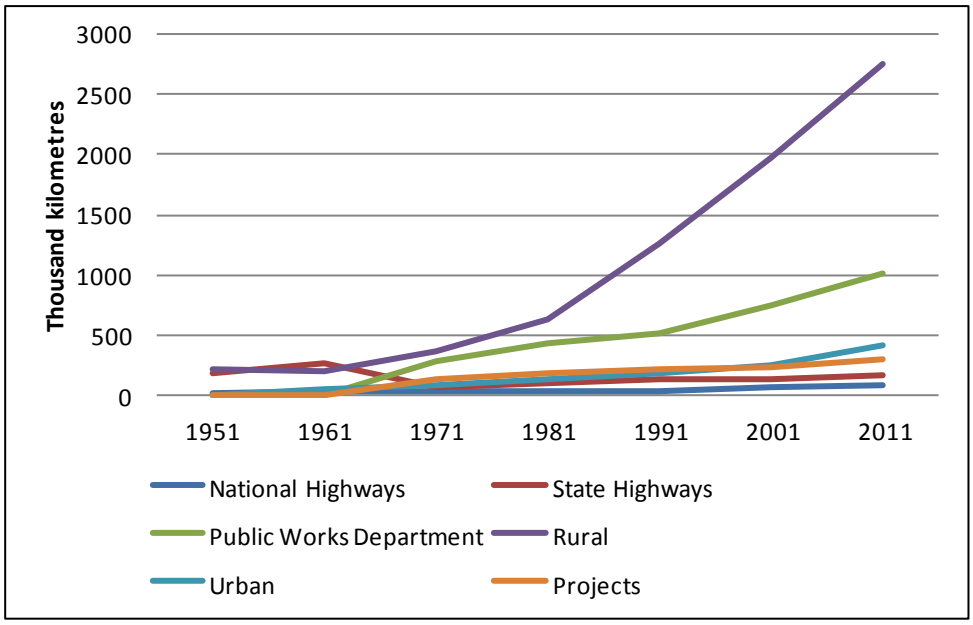
The transport sector utilised about 17% of total final energy consumed in India in 2005-06 (TERI, 2007). Within the transport sector itself, energy consumption is equally distributed between passenger and freight transportation (De la Rue du Can et al, 2009a). 95% of the energy consumed (3400 peta joules) is derived from petroleum products, of which 75% is derived from diesel, 19% from petrol and 1% from jet fuel (Ghate and Sundar, 2011). CNG (compressed natural gas) and electricity each contribute only 1% of energy to the transport sector. Road transport dominates energy consumption with 85.5% of petroleum fuels and 90% of all energy consumed in the transport sector (Ghate and Sundar, 2011). 'Increase of car ownership is considered the main driver of increasing energy use in the transport sector due to its high level of energy demand per passenger-km' (De la Rue du Can et al, 2009a:27). Energy consumption in railways was approximately 5.1% of total transport energy, and was comprised of 77.5% diesel and the balance, electricity (TERI, 2007). During 2004-05, the consumption of aviation fuel increased from 0.98 MT (1976-77) to 6.2 MT in 2005-06, with more than a 24% increase in the number of international and domestic flights (TERI, 2007). Clearly, the transport sector is overwhelmingly dependent on liquid petroleum fuels, i.e. petrol, diesel and jet fuel.

2.3 Likely impact of oil shocks on the transport system

The major vulnerabilities to oil shocks inherent in India's transport system include infrastructural, modal (passenger and freight), governance and geographical dimensions.

Transport **infrastructure** in India suffers from several problems. Two challenges highlighted by the Basic Roads Statistics of India are backlogs in road connectivity and maintenance of road infrastructure (MORTH, 2012a). Rural roads added 356,000 km in the five years from 2007-2011, of which only 38% are tar surfaced (MORTH, 2012a). Urban roads of which around 71 of total length were surfaced as of March 2011, added an additional 11,000 km during the same period. National Highways were added at the rate of 11km a day during 2011 to complete major road connectivity projects (NHAI, 2012). An additional 14,162 km of national highways were under construction as of September, 2012 (NHAI, 2012). Road construction and maintenance costs are vulnerable to oil price shocks, since the bitumen used for surfacing paved roads is derived from crude oil. The Indian road network is exceptionally vulnerable to oil price hikes since road length follows a growing trend (Figure 15).

Figure 15: Five yearly growth in road length by category (1951-2011)



Source: MORTH (2012a)

The low average annual growth rate of rail infrastructure supply (including both route network and rolling stock) at 3.9%, when compared to an annual transport demand growth rate of 11%, is considered a critical factor in the decline of Indian Railway's share of passenger and freight movement (MOR, 2009). Less than one third of the 64,460 route km is electrified (MOR, 2012). India's civil aviation industry is investing heavily in the upgrade of existing airports to international standards and encouraging private funding, including foreign direct investment, tax exemptions and 100% privatisation of airports, to increase the number of operational airports to 500 within the term of the 11th five-year plan (AAI, 2012). The industry is responding to the significant uptrend in air-based passenger and freight transport. This expenditure may be of less use in the future if domestic and international air travel is constrained by rising fuel prices (see Wakeford & De Wit, 2012).

The working group on urban transport in the National Planning Commission recommends that all Indian cities with a population of more than 2 million should start planning rail transit, and cities of more than 3 million should start constructing rail transit over the next five years, as a means of providing public transport to a rapidly urbanising population (Planning Commission, 2012). Buses account for 75% of motorised passenger movement on Indian roads. Delhi, the capital city, acquired a fleet of 6,000 new environmentally–friendly buses, nine rapid transit corridors, 60 new flyovers, and several thousand kilometres of new roads as preparations for the 2010 Commonwealth Games (Menon-Sen, 2010). A municipal ban on non-motorised cycle-rickshaws was declared unconstitutional by the Delhi High Court in February 2010 (UN-HABITAT, 2011). However, infrastructure to facilitate non-motorised transport in cities, such as walk-ways, bicycle paths and rickshaw lanes is starkly deficient.

The **mobility** of India's population that relies on motorised transport is highly vulnerable to oil price shocks, given the overwhelming reliance on liquid petroleum-fuelled vehicles. This applies to users of private motor vehicles and two-wheelers as well as buses and omni-buses. Public transport systems such as rail rapid transit are less vulnerable since they are run on electricity, which in India is predominantly (70%) derived from coal-based thermal generation plants (EIA, 2011).

The increasing reliance of **freight** on road transport presents a major challenge to the economy, both in terms of future fuel supply constraints and the impact of rising costs. Energy intensive air freight is most vulnerable to fuel prices among all modes of freight transport. Rising fuel prices would impact considerably on freight and logistics cost. Higher freight costs could be passed on to final consumers as higher retail prices for goods. Businesses and manufacturers, currently using goods vehicles may try to switch to the railway network, which may be ill-equipped to handle the increased freight demand. Air freight may end up being used only for the highest value goods in the long term, unless economically viable, alternative sources of aviation fuel are developed.

Currently in India, the same rail infrastructure is used for both passenger and freight transport which is sub-optimal (Pangotra and Shukla, 2012: 17). Additional aspects of lower average speed, unplanned stopping of trains and outdated technologies contribute to reduced efficiency of the railway system for both freight and passenger transportation (Pangotra and Shukla, 2012: 17). Dedicated freight corridors connecting ports and manufacturing centres, and high speed passenger trains connecting major Indian cities are recommended as solutions for reducing the growing share of road and air transport (Pangotra and Shukla, 2012; Ghate and Sundar, 2011). Six high capacity, high speed freight corridors, planned by the Ministry of Railways may provide a cost-effective means of addressing high growth in freight traffic in the future (Pangotra and Shukla, 2012). In the absence of such interventions, repeated and sustained oil shocks could prove catastrophic for India's growing economy.

Vulnerabilities can also be identified on a **geographical** basis. The bulk of petroleum products are consumed in urban areas, due to the increasing concentration of vehicles found there. High levels of urbanisation are increasing the sheer size of cities, which in turn is increasing city commuters' travel distances and times. Rural roads have seen stupendous growth in length since 1981 (Figure 15), connecting deep rural areas to rapidly modernising cities and towns. Without rail access, villages and their inhabitants are vulnerable to becoming disconnected again. Large freight volumes are carried across the length and breadth of the nation. Manufacturing centres are located in the interior of the country, requiring connectivity to mining towns, domestic consumers and to international suppliers and consumers via the country's coastal ports. Maximum domestic freight and passenger movement occurs along the Golden Quadrilateral and its diagonals. The six traffic-heavy routes in the country include the approved Western Corridor connecting Delhi and Mumbai (1500km) and Eastern Corridor connecting West Bengal and Punjab (1800km) (Pangotra and Shukla, 2012).

Short term, sudden **shortages** of fuel would have a drastic impact on transport. Localised fuel shortages could result in disabling immobility for road passengers within cities and between cities and villages. Sudden fuel shortages would cause interruptions in production processes as well as severe disruptions to logistics chains, resulting in shortages of various retail products, including food commodities. Similar to the energy sector, the transport sector in India is characterised by multiple government executive bodies which include the Ministry of Road Transport and Highways, Ministry of Shipping, Ministry of Civil Aviation and Ministry of Railways. These divisions have been deemed necessary to deal with the sheer scale of India's transport systems and requirements, but pose a challenge in terms of integrated planning.

Since the transport sector accounts for most of the oil consumption in India, it is also the most vulnerable to oil supply and price shocks. Increasing the share of public transport and rail-based movement, fuel efficiency improvements in vehicles and enhanced possibilities of substitution through the use of alternative fuels such as CNG (compressed natural gas), bio-diesel, and ethanol could reduce vulnerability of the transport sector (TERI, 2009). Risk free access to global energy-related technologies and expanding domestic energy sources by involving the Indian private sector

in exploration and production of oil will assist in achieving the optimal energy mix and enhance national energy security (TERI, 2009).

3. Agriculture

Agriculture, which is classified as one of the primary economic sectors, is quantitatively and qualitatively, one of the most important sectors of the Indian economy. It provides livelihood to more than 58% of the population and is the back-bone of several industries (NPOI, 2012). Agriculture and allied sectors contributed nearly 17% of GDP during 2008-09 (NPOI, 2012). Section 3.1 provides a brief overview of the agricultural system in India, while Section 3.2 describes its dependence on oil and explores the issue of national food security. Section 3.3 summarises the anticipated impacts of oil shocks.

3.1 Overview of agriculture

India has a total land area of 297 million hectares, of which nearly 180 million hectares (60%) is classified as farmland (DES, 2011). The sector is characterised by a large number of small farms, with land holding of less than 2 hectares, representing 80% of total agricultural land (De la Rue du Can et al, 2009b:28). Although land area under irrigation has increased to just over 45% by 2009, agricultural output remains heavily reliant upon the monsoon since approximately 55% of sown area is rain-fed (NPOI, 2012). A National Rain-fed Area Authority (NRAA) was set up in 2006 to give focused attention to the problem of the rain-fed areas of the country (NPOI, 2012).

The agricultural sector produces a wide range of commodities, including dairy; field crops (food grains including rice, wheat, maize, coarse cereals, pulses; oil seeds including groundnut and mustard; and cash crops including sugarcane, jute and mesta, and cotton); fisheries; and horticultural produce (fruits and vegetables) (NPOI, 2012). Food grains occupied 123 million hectares of land in 2008-09, of which rice was grown on 44 million hectares, wheat occupied nearly 28 million hectares, and pulses 23 million; oil seeds covered nearly 27 million hectares; and cash crops were on 16 million hectares of land (DES, 2011). India's food grain production has increased to more than 240 million tonnes in 2010, from 130 million tonnes in 1980 (FAO, 2011:3). Production of oil seeds, sugarcane and cotton has also increased, reaching 24 million tonnes, 355 million tonnes and 23 million bales, respectively, in 2006-07 (Planning Commission, 2007a).

Milk production, a key component of India's rural economy, rose to 113 million tonnes in 2010 from about 35 million tonnes in 1980 (FAO, 2011). Over the same period, demand for milk in India grew from 38kgs to 65kgs per capita (FAO, 2011:4). The milk revolution involves 10 million farmers in 80 000 villages, organised into thousands of milk co-operatives (FAO, 2011). India has also experienced vast changes in the fisheries industry in the last three decades. In 2010, the country was the world's eighth largest fish producer, with an annual production of more than 6.5 million tonnes (FAO, 2011:6). Inland fisheries contribute 60% to the production and the industry engages over 11.5 million people (FAO, 2011). Indian agriculture faces extreme water stress in the future as a result of increasing demand for food production and rising water consumption in urban areas. The sector currently supports "17% of the world's human population, with just 2.3% of the world's land area and 4.2% of the world's water" (Pandey, 2009:2).

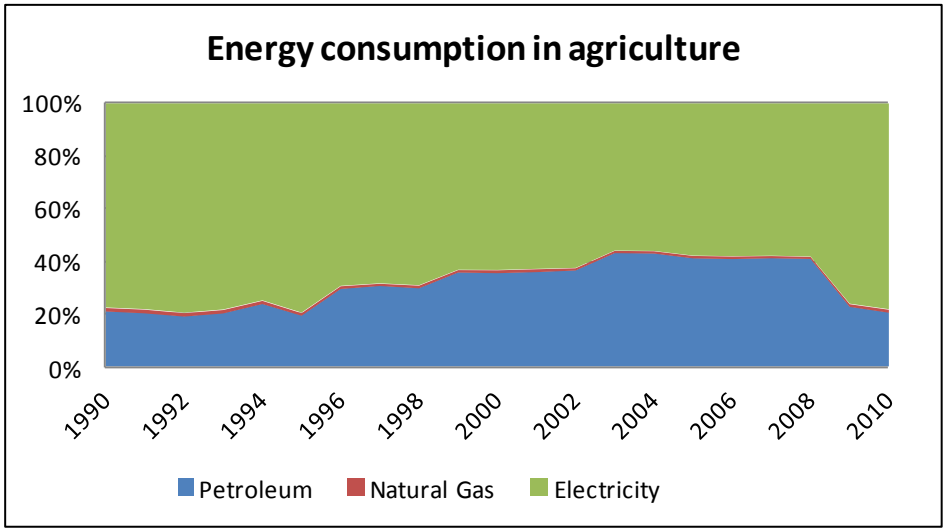
3.2 Oil dependence of agriculture

The agriculture, forestry and fishing sector accounted for 5% of total end use of energy and 9% of total primary energy use (IEA, 2012). Agriculture accounted for 19.6% of total electricity sales in

2010-11 for all economic sectors (MOSPI, 2012). As seen in Figure 16, the relative contribution of petroleum to total energy consumption in agriculture increased substantially over the past two decades. Natural gas contributes a minor share. The consumption of diesel had a sudden growth spurt during 1995-2000 and again during 2002-2004.

In 2010, just over 20% of the energy used by the agricultural sector was in the form of liquid petroleum fuels, while electricity contributed 78% and natural gas just under 2%. However, between 2003 and 2008, the share of petroleum fuels rose to more than 40% of total energy used in the agricultural sector. The sharp decline in the share of petroleum fuels from 2008 may be a data anomaly, as it is unlikely for energy use patterns to change so rapidly.

Figure 16: Energy consumption in agriculture, 1990-2010



Source: IEA (2012)

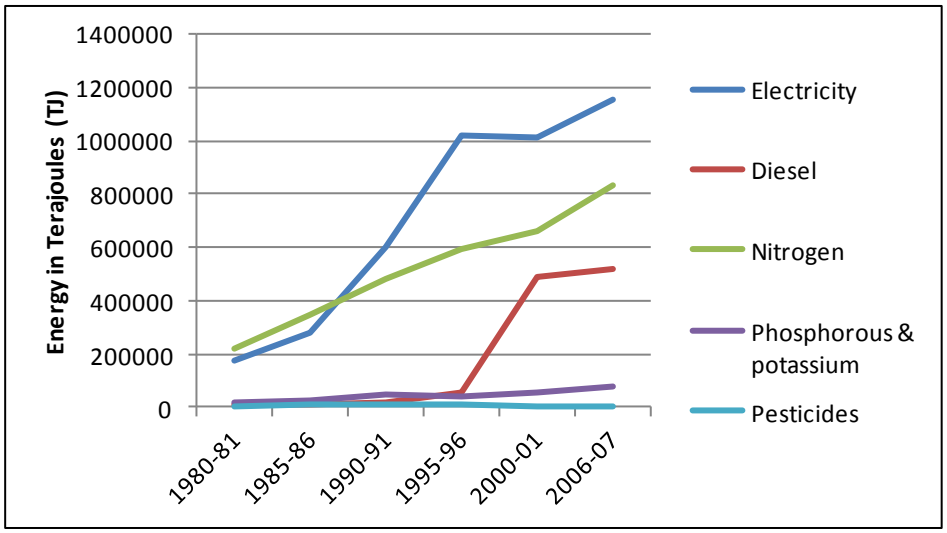
Production of food grains is the main driver of **energy consumption** in the Indian agricultural sector (De la Rue du Can et al, 2009b). Underlying the trend of increasing energy consumption in the food grain sector is a shift in the structure of direct energy use, away from animal and human labour towards increased reliance on electricity and petroleum (Jha et al, 2012). Electricity, used for water pumping for irrigation, is a major input to Indian agricultural activity. In 2004, electricity represented just over 50% of final energy use in the sector and accounted for 22% of all final electricity consumed in the country (De la Rue du Can et al, 2009b). Liquid petroleum fuels – especially high speed diesel – are used to power farm vehicles and machinery such as tractors, threshers and pumps.

The relative **capital intensity** (as measured by the capital/labour ratio) of Indian agriculture has increased considerably over the past three and half decades as farmers have progressively replaced human and animal labour with machinery. According to quantitative assessments, in 1970-71, agricultural workers contributed 15% and draught animals 45% to the total energy use in the sector, while electricity and fossil fuel provided 40% (Jha et al, 2012:62). By 2005-06, electricity and fossil fuel consumption rose to 86% of the total and human labour and draught animals fell to 6% and 8%, respectively (Jha et al, 2012:62). Demand for energy is expected to increase with continuous mechanisation of the sector (De la Rue du Can et al, 2009b).

The consumption pattern of different energy sources is depicted in Figure 17. The consumption of fertilizer (nitrogen, phosphorous and potassium) increased consistently during the period 1981 to 2007. The total **commercial energy** input to Indian agriculture has increased six-fold from 425,377

Tera Joules (TJ) in 1980-81 to 2,592,821 TJ in 2006-07 (Jha et al, 2012:63). The consumption of energy per hectare of net sown area increased from 3 thousand MJ to 18.5 thousand MJ during the same period (Jha et al, 2012:63). This shift is attributed to increase in cropping intensity and a shift towards energy-intensive crops (Jha et al, 2012).

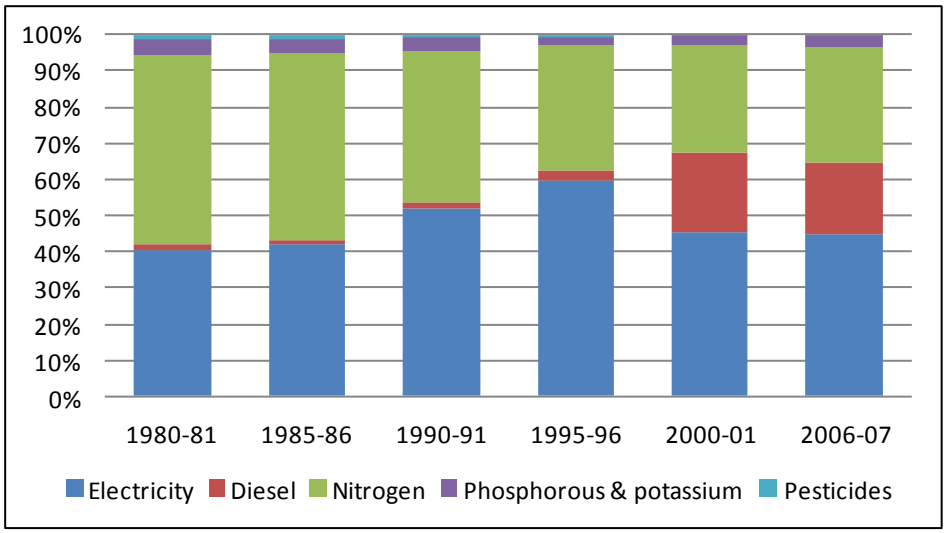
Figure 17: Temporal behaviour of commercial energy use in Indian agriculture, 1980-2007



Source: Jha et al, 2012 (Based on DES, 2011)

The share of different sources of commercial energy use is shown in Figure 18. In the 1980s, indirect energy use in the form of fertilizers contributed more than 56% of total energy use, which declined to just over 35% by 2006. The share of diesel has seen a massive increase from 1.5% in 1980 to 20% of the total by 2006. The indirect use of energy in the form of pesticides has fallen significantly, from 1.27% in 1980-81 to 0.18% in 2006-07. In the current mix, electricity, fertilizer and diesel are the main sources of commercial energy for agriculture.

Figure 18: Sources of commercial energy use in Indian agriculture, 1980-2007



Source: Jha et al, 2012

National food security

The dependence of agriculture on oil has significant implications for national food security. Food security can be analysed on different scales of aggregation. The remainder of this subsection considers food security at the national level, while household level food security is discussed in Section 5.2. At the national level, food security has two determinants: (1) the capacity of the country to be self-sufficient in food production; and (2) the ability of the country to afford food imports where necessary or desirable.

India witnessed a green revolution in the 1970s which translated into wider dissemination of technology and early reforms, and agricultural GDP growth rates of more than 3.5% from 1981-82 to 1996-97 were attained (Planning Commission, 2007a). However, growth of the agricultural GDP had decelerated to just over 2% from 1997-98 to 2004-05. The Indian government targeted national-level food security in the 11th Five Year Plan with the launch of the National Food Security Mission (NFSM) as a national scheme to raise production levels by 20 million tonnes by the end of 2012, from 217 million tonnes in 2006-2007 (Planning Commission, 2007a). This target was achieved well within time; food grain production rose to 240 million tonnes in 2010 and the country is now self-sufficient in rice and wheat, and exports a range of agricultural products (FAO, 2011). The NSFM concentrated on the large potential of yield gaps in eastern and central Indian states by increasing seed replacement, and replacement of older seed varieties with newer ones, and enhancing groundwater utilization (Planning Commission, 2007a).

India relies on imports for some agricultural products. The country's share of agricultural imports in national imports declined from 6.6% in 2001-02 to 3.5% in 2010-11 (DES, 2011). Indian agricultural imports are dominated by vegetable oils, followed by pulses, sugar and cashews. The country's share of agricultural exports in national exports fell from 14.2% in 2001-02 to 10.8% in 2005-06 and remains under 11% in 2010-11 (DES, 2011).

Continued national food self-sufficiency clearly depends on access to affordable, quality inputs (such as fertilisers, pesticides, and machinery) for agricultural production. According to DES (2011), total consumption of fertilisers in 2011 stood at 28 million tonnes and imports stood at just over 12 million tonnes. India does not produce any potassium fertilisers but produces 12 million tonnes of nitrogen fertilisers and 4 million tonnes of phosphorous fertilisers (DES, 2011).

Despite current food self-sufficiency, 55% of sown area in India continues to be rain fed, which means that productivity is highly dependent upon monsoon rains and is vulnerable to climate variability and climate change. India will need to double its food grain production by 2050, to nearly 500 million tonnes, in order to feed its growing population (FAO, 2011:5). Declining groundwater tables and increasing deficiencies in the soil will require increasingly higher levels of direct and indirect energy inputs, unless effective energy saving technologies are implemented (Jha et al, 2012). The second important determinant of national food security is India's capacity to import food products. This depends on international food availability and prices as well as the strength of the domestic economy, in particular the balance of payments and the level of the exchange rate (see Section 4 below). These aspects of the macro-economy are likely to come under pressure from any future oil price shocks.

3.3 Likely impact of oil shocks on agriculture

It is clear that Indian agriculture has become more energy dependantand current trends indicate that energy dependence will increase further (Figure 16). An oil price shock will also impact the agricultural sector through direct channels (higher prices for diesel used in farm machinery) and indirect channels (electricity and urea for fertilisers and pesticides) (Sihag et al, 2002). In addition,

rising transport costs will add to the prices of chemical inputs, and raise the costs of transporting produce to food processors, wholesalers and markets. In the short run, oil price-related disruptions will reduce farm income of farmers (Jha et al, 2012:67). In the long run, a sustained rise in fuel prices may change input-use and production practices (Jha et al, 2012:65). Persistent higher oil prices and shortages of oil might encourage farmers to revert to more labour-intensive and organic methods of production that rely less on petroleum based fuels and pesticides, but which may result in a decrease in output in the short term (Wakeford, 2012). Technologies which increase the fuel-efficiency of farming machinery and policies for promoting the use of renewable energy (solar and biogas-based) in the agricultural sector would counter current oil-dependence, at least in the direct energy component of production. If production costs rise faster than sales prices, then agricultural output will decline. Sale prices for a majority of the output are regulated through the Minimum Support Price (MSP), designed to protect farmers' interests. Hence a fall in production is contingent on the government not raising MSP with rising costs and being fiscally responsible. Higher agricultural output prices will have serious implications for food security, poverty status and industrial production that is reliant upon agricultural produce as an input (Jha et al, 2012).

Individual Indian farmers are price-takers and are not able to pass on cost increases to consumers. This exposes farmers to financial distress if production and transportation costs rise too much. The food grain price index increased by only 12% between 2001 and 2006 while the price indices of diesel, electricity and fertilizers increased by 86%, 45% and 10% respectively (Jha et al, 2012:65).

A sudden shortage of diesel in rural areas of India would compromise agricultural activities, especially if it occurs at the time of planting or harvesting. Farmers who need diesel for tractors and irrigation pumps would have to compete with freight companies and private operators of passenger transport. Oil shocks would also have a negative impact on the distribution of farming products to processing facilities and markets in towns and cities. India already suffers from a poor food distribution system, which is given as the leading cause of high levels of malnutrition among the country's poor, despite self-sufficiency in the production of food staples (Thomson, 2012).

4. Macro-economy

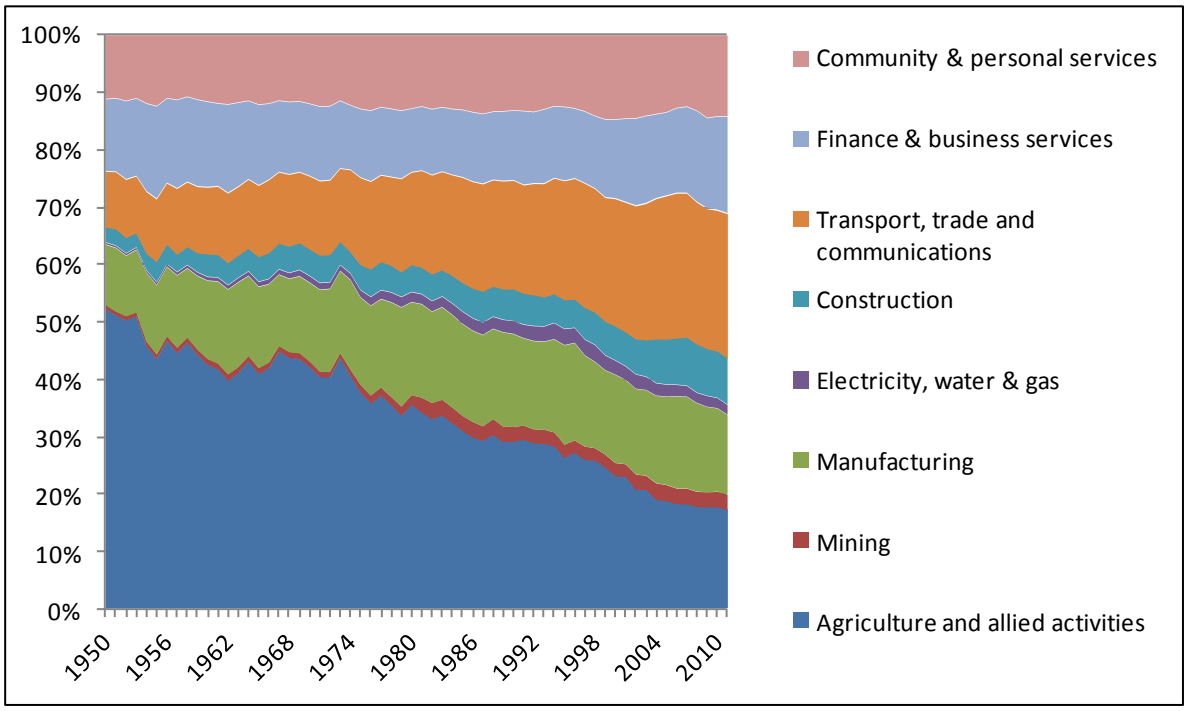
This section begins with a brief overview of the structure of India's macro-economy. It then details the economy's energy intensity and oil dependency. The third subsection lists the main macroeconomic strengths and vulnerabilities to oil shocks. The fourth subsection discusses the likely macroeconomic impacts of oil price shocks in India, drawing on historical experience.

4.1 Overview of the macro-economy

The evolution of the broad structure of the Indian economy between 1950 and 2010 is represented in Figure 19, which shows the relative components of the Gross Domestic Product (at factor cost) by the eight one-digit economic sectors. The most significant shift has been the decline in the relative importance of agriculture and allied activities, from over 52% of GDP in 1950 to 17.7% in 2010. The largest gains were in transport, trade and communication (more than doubling in relative size from 10% in 1950 to 25% in 2010), construction (3% to 8%), electricity, gas and water (0.2% to 1.7%) and mining (from less than one percent in 1950 to 2.7% in 2010). Community services grew from 11% of the GDP to 14%, while finance and business services grew from 13% to 16% in 2010. Manufacturing has also increased significantly, from 10.6% to 14.5% of GDP. The services sector now holds a 55% share of the GDP, and includes trade, hotels and restaurants; transport, storage and communication; financing, insurance, real estate, and business services; and community, social and personal services, as per National Accounts classification of services (MOF, 2012) Agriculture is the second largest

sector while mining is the second smallest sector. Overall, the economy is dominated by agriculture in terms of employment and the services sector in terms of relative share of the GDP.

Figure 19: Sectoral components of GDP, 1950-2010



Source: Reserve Bank of India (2012a)

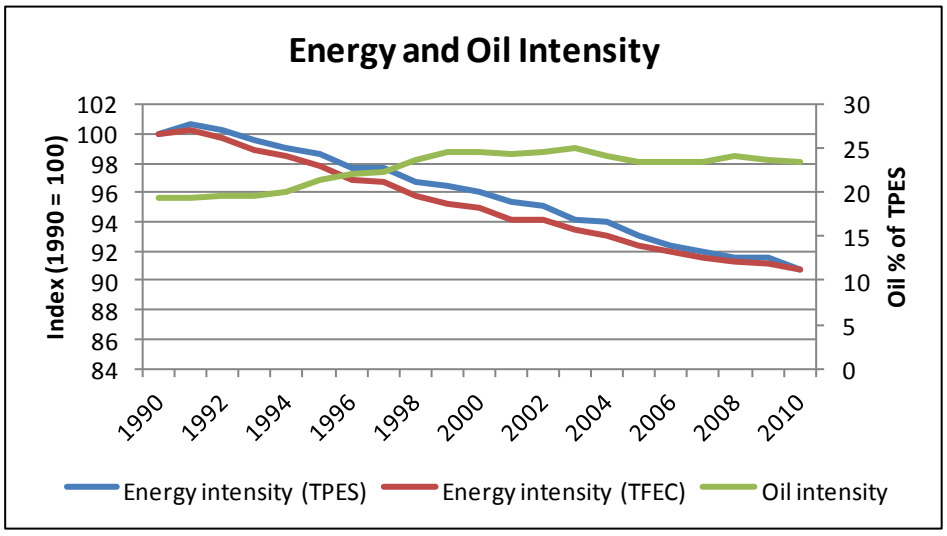
4.2 Oil dependence of the macro-economy

In comparison with China, the United States and the European Union, the Indian economy is characterised by low **energy intensity**, when traditional fuels such as biomass are excluded (Rao et al, 2009). Energy intensity for industry, transportation and agriculture has been declining steadily since the 1990s (Figure 20). India's energy intensity, measured as the ratio of total primary energy supply to real GDP, has declined by almost 10% since 1991. A clear decoupling between total primary energy use and GDP growth is evident since 1990: over the period 1990 to 2005, GDP had multiplied by a factor of 2.3 while energy consumption had grown by a factor of only 1.9 (De la Rue du Can et al, 2009a). This partly reflected a structural shift in the composition of the economy away from agriculture to services, which are less energy intensive. Improvements towards energy efficient technologies, demand side management and energy conservation measures will help reduce oil dependence.

India's *oil resource dependence* is high. According to IEA figures, oil in 2010 constituted approximately 23.4% of India's total primary energy supply (TPES), up from 19.4% in 1990. Oil intensity of the economy rose in the 1990s and has declined steadily since 2000 to remain below 24% of the TPES in 2010.

India has a very high degree of *oil import dependence*: more than 70% percent of crude oil and part of the petroleum products are imported (MOSPI, 2012). Despite aggressive oil exploration initiatives by the government, Indian oil production, currently at 1 million barrels per day, is expected to grow at an average annual rate of less than one percent through 2035 (EIA, 2011).

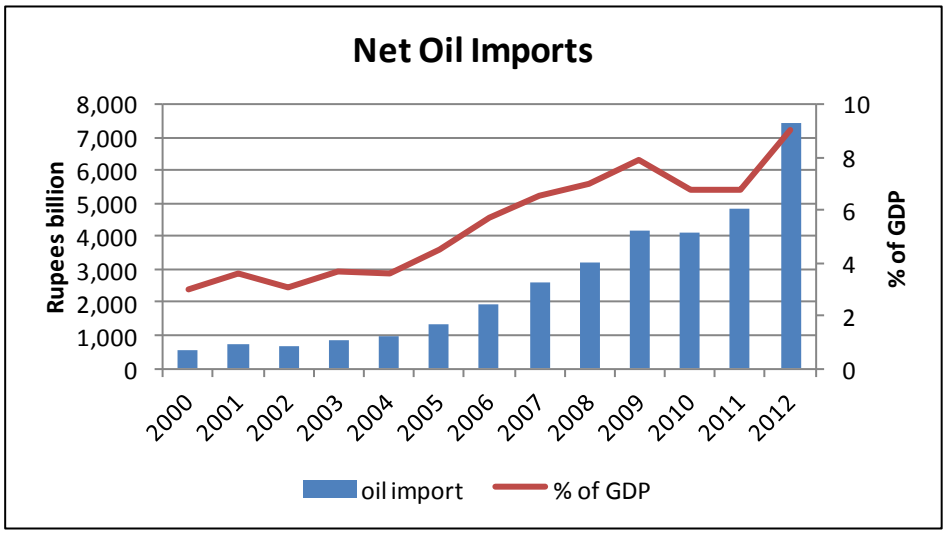
Figure 20: India's energy and oil intensity, 1990-2010



Source: IEA (2012), RBI (2012) and author's calculations
Note: The energy intensity indexes are derived from the ratios of total primary energy supply (TPES) and total final energy consumption (TFEC) to real GDP, respectively; oil intensity is the percentage share of oil in total primary energy supply (TPES).

The nominal value of India's crude and refined oil imports rose fairly rapidly between 2005 and 2009 (see Figure 21), thanks to a combination of rising consumption (driven by economic growth and an expanding population) as well as a steadily rising oil price. In 2009 the country spent nearly Rs4200 billion, or 8% of GDP, on oil imports, which represented the single largest import item on the balance of payments. In 2010, as a result of the recession, oil imports fell slightly to 7% of GDP. In 2010, crude oil and petroleum products constituted just over 30% of import commodities; the next single commodity import category, gold and silver, stood at 8% (DGFT, 2011). In 2012, oil imports grew to an all-time high of nearly Rs7400 billion, or 9% of GDP.

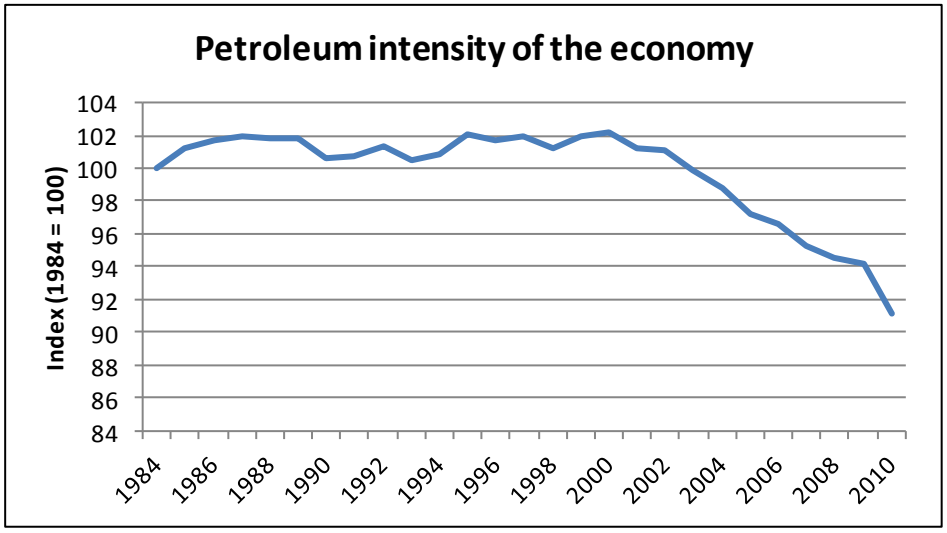
Figure 21: Net crude and refined oil imports, 2000-2012



Source: DOC (2012) and RBI (2012)

A final measure of the oil dependence of the Indian macro-economy is provided by the ratio of petroleum product consumption to real GDP. Figure 22 shows that this measure of petroleum dependency decreased slightly in the early 1990s, increased from the mid-nineties to reach a peak in 1999-2000, after which it declined from 2002 by an average of 1.1% per annum and a cumulative 10 percentage points by 2010. This is an illustration of *relative resource decoupling* (Fischer-Kowalski & Swilling, 2011):[2] although absolute consumption of petroleum products rose between 1998 and 2010, consumption relative to real GDP fell notably. This relative decoupling can partly be explained by the economic dominance of the services sector (with low petroleum intensity). Nevertheless, this decoupling achievement bodes well for the potential to reduce future petroleum consumption while attenuating negative impacts on economic activity.

Figure 22: Petroleum intensity of the economy, 1984-2010



Source: Author's calculations based on IEA (2012) and RBI (2012)

4.3 Strengths and vulnerabilities of the macro-economy

The major strengths and vulnerabilities of the Indian macro-economy in the face of international oil price shocks, as of 2012, are as follows:

- The Indian economy was one of the fastest growing in the post-crisis period after 2008 (RBI, 2012b), indicating its resilience in the face of external shocks.
- International trade was at 53% of GDP in 2011-12, up from 37% in 2004-05 (MOF, 2012). This exposes the economy to the effects of higher transport costs if oil prices rise and to disruptions in supply chains if there are shortages in the global or regional oil market.
- The euro zone crisis and global economic uncertainty are seen as contributing factors to the current slowdown in growth, higher current account deficit and reduced capital inflows (MOF, 2012).
- The current account deficit (CAD) stood at $45.9 billion in 2010-11, up from $38.2 billion in 2009-10 but reduced marginally as a ratio of GDP to 2.7% as compared to 2.8% in 2009-10 (MOF, 2012). In 2011-12, the CAD increased to $78.2 billion or 4.2% of the GDP (RBI, 2012b). This is reasonably low compared to many other lower middle income countries, but nevertheless

[2] Fischer-Kowalski and Swilling (2011: 4) define *resource decoupling* as "reducing the rate of use of (primary) resources per unit of economic activity."

presents a risk to macroeconomic and exchange rate stability, especially in the face of future oil price shocks.

- The widening of the CAD is mainly on account of a higher trade deficit: of 7.8% of GDP in 2010-11 and 10.3% of GDP in 2011-12, and contributing to a growing imbalance in the country's balance of payments (RBI, 2012b).
- Exports have crossed $200 billion for the first time in 2010-11, driven by higher value-added engineering and petroleum products, and diversification to developing country export destinations.
- Despite diversification of exports to Asia and the Association of Southeast Asian Nations (ASEAN), a decelerating growth rate of exports to the EU and EU-dependent markets, and a 53.8% growth in imports of gold and silver, resulted in an all-time high merchandise trade deficit of $148.1 billion in 2011-12, exhibiting a 40.3% increase from the previous year.
- Oil imports accounted for 30% of total imports in 2000-01 and in 2011-12, but the share of crude and petroleum products in total exports increased from 4.3% to 20.9% over the same period.
- The financial account of the balance of payments increased to $67.8 billion in 2011-12, up from $62 billion in 2010-11 (RBI, 2012b). As a ratio of GDP, net capital flows stayed at 3.7%. The increase is mainly on account of trade credits and loans, since foreign institutional investment flows declined in 2011 (MOF, 2012).
- The rupee exchange rate touched an all-time low of ₹ 54.3 per US$ on 15 December 2011, although the depreciating trend was checked and slightly reversed through RBI intervention.
- The fiscal deficit rose to 6.5% of GDP in 2009 as a consequence of the Global Financial Crisis, decreased to 4.9% in 2010, returning to 5.9% in 2011.
- India's external (foreign) debt in 2011-12, at 20% of GDP, is comparatively low by international standards, although it has increased from 17.8% in 2010-11. Foreign exchange reserves provided a cover of 85% of the total debt stock in 2011, down from 99.5% in 2010.
- A key strength of the Indian economy is the high domestic saving rate, which as a ratio of GDP has remained above 30% since 2000, and stood at 32.3% in 2010. Household saving has remained 22% of GDP since 2000, reaching a peak of 25.4% in 2009 (RBI, 2012b). To some extent this protects consumers from oil price shock impacts such as higher costs of living, higher interests rates and falling real incomes.
- Inflation as measured by the wholesale price index (WPI) remained uncomfortably high, at 9% during most of the 2011-12 fiscal year and briefly touched double figures in September 2011. Monetary policy was tightened by RBI to control inflation, especially food inflation, and by the year's end there was a clear slowdown (MOF, 2012). Reserve Bank measures included a cumulative 375 base points increase in the repo rate to 8.5% by the end of 2011, although this was offset to an extent by a reduction in the cash reserve requirement ratio from 6% to 5.5%.
- Major contributing factors to high inflation include higher primary articles prices (for vegetables, eggs, meat and fish) due to changing dietary patterns of consumers; increasing global commodity prices (for metals and chemicals) leading to higher domestic manufactured prices; and persistently high international crude oil prices since 2011 (averaging $111 per barrel) (MOF, 2012).

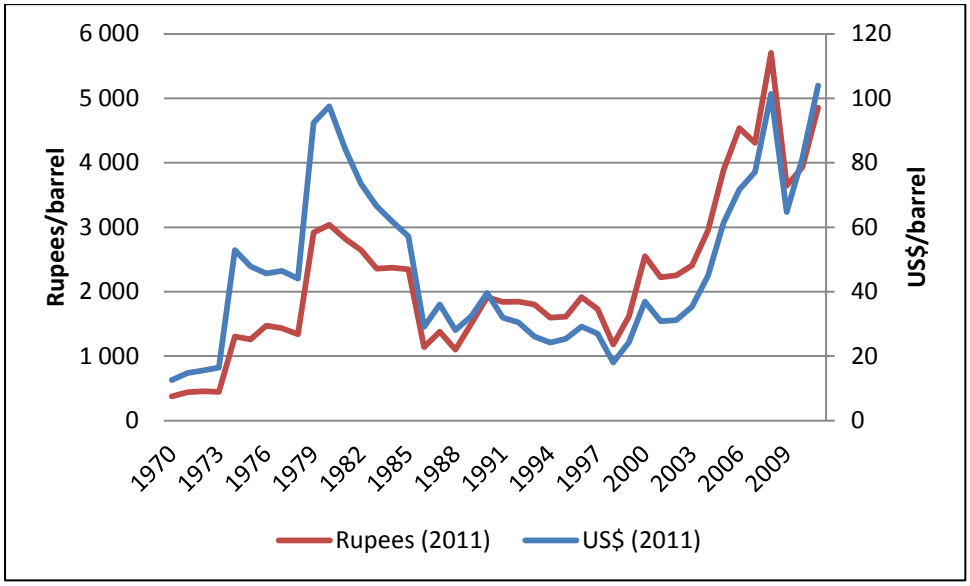
4.4 Likely impact of oil shocks on the macro-economy

The direct impacts of oil price shocks occur via higher fuel prices and have reverberations on several important macroeconomic variables. India is a price taker on the international oil market, but exercises discretion in passing on international oil price shocks to domestic prices. Domestically, the downstream liquid fuels industry is subject to extensive government regulation. Prices of petroleum fuels (petrol, diesel, kerosene and LPG) are administered by the Indian Government, which imposes various levies and taxes and determines retail and wholesale margins, over-and-above a 'basic fuel

price'. The administered price system for oil in India is supported by subsidies, even as oil revenues constitute a sizeable portion of the total revenues for government (Bhanumurthy et al, 2012). The oil pass-through policy is under reform, with important implications for the impact of international oil prices on macroeconomic objectives for growth, inflation and equity (Bhanumurthy et al, 2012). The pricing of petroleum products was scheduled to be completely deregulated from April 1, 2002. However, it only enabled the Oil Marketing Companies to 'freely determine retail prices of some petroleum products based on an international parity pricing formula, while the government continued to regulate the prices of other petroleum products' (Mandal et al, 2012). Bhanumurthy et al's (2012:38) results show that deregulation of domestic oil prices over the 12th Five-Year Plan (2012-17), as is currently underway, will reduce growth while increasing inflation. However, it will also result in an improved fiscal deficit and marginally, the current account deficit. In the case of partial pass-through, in the medium to long-term, an increased subsidy bill could potentially reduce public investment, thus adversely affecting growth.

The basic fuel price is influenced by two primary factors: the dollar price of crude oil traded on international markets; and the rupee/dollar exchange rate. Volatility in both of these variables has historically had a significant impact on the rupee denominated price of oil (Figure 23). In recent years, the real price of oil in rupees has risen to nearly double the previous record level set after the second oil price shock in 1979/80, largely because of the long-term depreciation of the rupee against the dollar.

Figure 23: Real oil price in 2011 dollars and Indian rupees, 1970-2011



Source: IMF (2012), World Bank (2012) and own calculations

In general, the effect of an oil price shock on the macro-economy of an oil-importing country has been to reduce growth, increase inflation, worsen the fiscal deficit and increase foreign debt as a percentage of GDP (Sihag et al, 2002). The Indian economy has followed a similar trend, confirmed by an analysis of the time series of the above macro-economic indicators. Declines in GDP after the oil supply shocks in 1973, 1979-80 and 1991 were followed by periods of economic recovery (Sihag et al, 2002). Furthermore, a large share of Indian oil imports is sourced from the Middle East, making the country's economy vulnerable to political disruptions in the region. In 1991, GDP slumped from 5.5% to 1.3%, inflation increased to 14% and foreign debt to GDP stood at 39% after the Gulf War (Sihag et al, 2002). In future, international oil price shocks could have significant impact on inflation and inflation expectations in India (Mandal et al, 2012). The Indian economy was able to cope

reasonably well with the gradual increase in oil prices between 2003 and 2008, but suffered from the effects of the global recession in 2009-10 as demand for India's exports by the western developed economies declined.

India's high economic growth rate in the last decade has been achieved on the back of a strong services sector but has also relied on oil-dependent transport services. A sharp oil price increase may curb demand and boost inflation. A government decision to expand refining capacity and exports of petroleum products due to expectations of greater demand in the Asia-Pacific region increases the manufacturing sector's vulnerability to sudden oil price increases, which would dampen foreign demand for India's exports. Following an oil price shock, the residential sector will experience hikes in the price of transportation fuels, and impacts from increases in the prices of kerosene (predominantly rural use) and LPG (urban and semi-urban use), which are currently still subsidised.

5. Society

This section provides an overview of several important features of contemporary Indian society that are relevant to understanding potential social vulnerabilities to oil price and supply shocks. Section 5.1 presents data on the extent of poverty and inequality. Section 5.2 discusses food security at the household level. Section 5.3 highlights some relevant features of human settlement patterns. Finally, Section 5.4 discusses the issue of social cohesion and several factors that may undermine it.

5.1 Poverty and inequality

Poverty renders people more vulnerable to economic shocks, including rising transport and food costs. Furthermore, a society characterised by a high degree of inequality can be expected to experience greater social stresses and tensions in times of economic adversity. The *poverty headcount rate* for India indicates that more than half the population lives below the World Bank delineated poverty line. In 2010, 33% of the population lived below $1.25 per day; while 69% of the population lived below $2 per day (World Bank, 2012). Among the lower middle income countries, only the Republic of Congo, Nigeria, Zambia and Timor-Leste fared worse than India in terms of the percentage of the population living below $2 a day. The Indian Planning Commission recently defined the poverty line at a highly controversial Rs859.6 of monthly consumption in urban areas, and Rs672.8 in rural areas (IBNLive, 2012). At the current dollar/rupee exchange rate, this translates to living on less than half a dollar per day.

As an indicator of inequality, the poorest 40% of the population held only a 19% share of household income during 2000-2010, while the richest 20% held a 45% share of household income (UNICEF, 2012). The country's GINI co-efficient, a measure of income inequality, stood at 0.334 in 2009, and is quite low when compared to other countries in the same income category (World Bank, 2012).

The centrally-funded National Social Assistance Programme (NSAP) provides social grants to individuals below the poverty line through three components: the National Old Age Pension Scheme, the National Family Benefit Scheme (in case of death due to natural or accidental causes of death of the primary breadwinner of a household) and the National Maternity Benefit Scheme (MORD, 2011). However, there are substantial gaps in coverage and overlapping of benefits, which pose a large risk given the rapidly changing demographics and economic conditions in the country (Planning Commission, 2007b).

Poorer households are in general more vulnerable to increases in energy, transport and food prices. An impact of higher oil prices would be to stem the transition up the energy ladder. People would continue to use kerosene and biomass and not graduate to LPG and electricity.

The National Sample Survey reports on the following trends based on a survey of monthly consumer expenditure across rural and urban households (NSSO, 2011:31):

- The average rural household spent nearly 57% of expenditure on food during 2009-10 (of which 14% is for cereal, 8% is for milk and milk products, and 8% is for vegetables). Fuel for cooking and lighting accounted for nearly 8%; clothing and footwear accounted for 6%; while transport costs at 3.5% constituted roughly the same as expenditure on education.
- The average urban householder spent 44% on food (of which 8% was on cereals and 7% on milk and milk products); fuel for cooking and lighting was at 7% of total expenditure; transport costs constituted 5.6%; and education a sizeable 8% of total expenditure.

Food is the largest expenditure item for households, although energy and transport costs are also significant, with urban households spending more on transport than rural households.

5.2 Household food security

Food security is a vital condition for human well-being and social stability. Despite increased agricultural production due to improved infrastructure and interventions, Indians suffer from high levels of household food and nutritional insecurity. According to the World Bank statistics, 19% of the Indian population is under-nourished (World Bank, 2012). However, in 2005-06, 33% of the adult population had a body-mass index below 18.5 (cut-off for adult malnutrition) and 46% of children under the age of 3 were underweight (Planning Commission, 2007b). The low levels of nutrition among India's poor are linked to several vulnerabilities: low and stagnating incomes among the poor contributing to low purchasing power; lack of social protection for more than 93% of the population working in the informal sector; a growing feminisation of agriculture with growing male migration to cities; and an inadequate and under-funded public health system (Planning Commission, 2007b). Despite rapid economic growth, India's rate of malnutrition is worse than for Africa on average, and among the worst in South Asia (Planning Commission, 2007b).

Household food security and nutrition is high on the political agenda. Diet surveys conducted across all 25 states provide detailed information with regards to malnutrition being linked to diet composition, resulting in deficits in energy and micro-nutrient intake, especially among children, adolescents and women. Two inter-linked trends emerge, based on National Sample Survey (NSS) data over a twenty year period (1983-2004): per capita availability of cereals has declined, while consumption of non-cereals has not grown to compensate this decline; rural calorie and protein consumption declined by 8% during the period, while urban calorie consumption declined by 3.3% and protein consumption stayed the same (Planning Commission, 2007b).

Oil price shocks carry three major threats to household food security in India. The first is linked to food production and increased food prices, through oil-dependent direct and indirect energy costs. The second threat is linked to the government-sponsored public distribution system, whereby the central government is responsible for the procurement and transportation of food grains to public distribution centres. Oil shocks and fuel shortages may hamper the already inadequate food distribution system, which is designed to support individuals below the poverty line. The third threat is of falling employment levels and incomes as a result of the negative macroeconomic consequences of oil shocks.

5.3 Settlement patterns

Human settlement and migration patterns play an important role in Indian society's dependence on liquid fuel based transport and therefore in its vulnerability to oil supply disruptions and price

shocks. The two predominant trends shaping the country's settlement patterns are: (a) an alarming rate of urbanisation; and (b) a great diversity in the spatial aspect of urbanisation, which includes both an increase in congestion in older sections of cities, as well as urban sprawl. India's urban population stood at nearly 31% of the total Indian population in 2010 (World Bank, 2012) which is comparable to other developing Asian countries like China (32%), Indonesia (37%) and Pakistan (35%). However, almost 69% of the urban population is concentrated in large cities and city agglomerations, reflecting a polarization of employment opportunities (Planning Commission, 2007a). Analysis by the Indian Institute of Human Settlements shows that "urban areas account for a disproportionately small amount of India's terrain when compared with their significant and rising share of economic output" (IIHS, 2011: 4). The top 100 cities of India accounted for 16% of the population, produced 43% of total economic output, and occupied only 0.26% of the land (IIHS, 2011:5). The figures for the distribution of urban and rural populations are symptomatic of a country which is moving away from a rural-agrarian to an urban-industrial/services dominated economy. The second trend of increasing sprawl among the million-plus cities is based on an analysis of changes in land cover over time. The growth of built-up areas outside of formal administrative boundaries, which is faster than the actual growth in population, is leading to less compact cities with large transport, infrastructure and energy needs (IIHS, 2011).

The sprawling face of Indian cities and towns is also characterised by a phenomenal growth in private motor vehicle ownership, among those who can afford it. Statistics on urban demographics indicate that most new settlements occur in under-serviced informal areas, or slums. Slums are not necessarily located on the periphery of cities as is the case in South Africa and Brazil, but they do represent concentrations of poverty in Indian cities and raise significant planning, management and developmental challenges. Although 40% of the country's slum population is located in million-plus cities, 80% of India's urban poor reside in cities with populations of less than a million (IIHS, 2011). Both the affluent and the poor are vulnerable to rising fuel and transport costs and fuel shortages, although the poor, and more specifically recent migrants, are more likely to seek informal employment within walking or cycling distances. The current and desired rate of development of cities to accommodate the growing rural-urban migration would be directly and indirectly vulnerable to future oil shocks through energy and material requirements for building of urban roads; expansion of services such as water supply, sanitation, solid waste management, drainage and sewerage; as well as boosting a highly inadequate housing stock.

Despite excellent railway connectivity across the nation, deep rural residents are in some ways more dependent on motorised travel than urban areas, as distances to towns with railway stations and economic opportunities may be larger than distances typically travelled within cities. About 70% of Indians reside in more than 550,000 villages, while the urban population lives in more than 200 towns and cities (BSCAA, 2012).

5.4 Social cohesion

The ability of a society to withstand social and economic shocks depends *inter alia* on the degree of social cohesion. Social cohesion in India is affected by numerous factors including the ethnic composition of the society; political and social dispensation which is linked to caste, religion and language; inequality, poverty and vulnerability; and migration and immigration. Culturally, India has absorbed influences from several waves of invaders including the Aryans, the Mongols, the Afghans, the Greeks, the Mughals, and most recently, the British. The national census does not recognise racial or ethic groups, and yet India is estimated to be home to more than 2000 ethnic groups (BSCAA, 2012). The government recognises 18 official languages, with Hindi, the most widely spoken, declared as the national language. The caste system is officially illegal but remains the basis for high levels of discrimination, especially in rural areas. Marginalised social groups in India can be

defined by their caste, tribal, minority or developmental status. The government has instituted strong social justice policies to improve access to social and economic opportunities by all groups, including persons with disabilities, older persons, street children, beggars, and victims of substance abuse (Planning Commission, 2007c). While 80% of the country's population is Hindu, India also holds one of the world's largest populations of Muslims, at more than 138 million (BCSAA, 2012). Hindu-Muslim relations grew tense in 1992, following the demolition of a mosque in Northern India by Hindu nationalists, and subsequent religious riots, in which thousands of Muslims were killed. In 2006, 2008 and 2011, bomb blasts in Mumbai exposed the vulnerability of India's cultural and socio-economic melting pots, its cities, to terrorism. Such events fuel political and social instability, and erode social cohesion.

India has enjoyed a stable democracy since 1947 with free and fair elections held at least every five years. Since independence from the British, the Indian National Congress has ruled India with the exception of short periods in the 1970s and 1980s and in 1996. From 1998-2004, the Bharatiya Janata Party (BJP) led a coalition that governed India. India has 29 states (including the National Capital Region of Delhi) and 6 union territories. States have a governor as a representative of the President and often a bicameral legislative system, while union territories are governed directly by the central government. States are created on a linguistic basis and the creation of 3 new states in 2000 is indicative of state politics growing in significance when compared to national politics. The level of services available to urban householders when compared to their rural counterparts is a source of social and economic stress. A declining child sex ratio (from 927 in 2001 to 914 in 2011) (ORGI, 2011) is indicative of high levels of female infanticide and foeticide, across rural and urban areas, as well as different economic groups. In recent times this has led to even higher levels of female abuse at a household level, and migration of women from female-populated states and neighbouring countries to those states with fewer females per male (such as Punjab and Haryana).

Recent years have witnessed an increase in immigration from neighbouring Bangladesh into large Indian cities, in particular those in North-East India. This trend is overlaid upon decades of domestic migration across different Indian states, and adds further complexity to the socio-political situation of states which also have sizeable tribal populations, who were denied democratic rights in the pre- and post-independence periods. Immigration from neighbouring countries has been driven both by push factors (such as political and economic upheavals in Bangladesh, Sri Lanka and Nepal) as well as pull factors (e.g. the relative size and strength of India's economy within the sub-continent).

6. Summary

India's strengths and vulnerabilities vis-à-vis oil shocks in each of the five socioeconomic subsystems are summarised in Table 1. These subsystems are not isolated from one another, but are connected by many linkages and feedbacks, which in many ways intensify the dependencies on oil and magnify the vulnerabilities to oil shocks.

Table 1: Summary of India's key strengths and vulnerabilities, and likely impacts of oil shocks

Subsystem	Strengths	Vulnerabilities	Impacts
Energy	• high share of combustible renewables and waste in primary energy (25%) • electricity minimally dependent on imported oil • substantial oil and large coal reserves • abundant solar and hydro resources • overseas oil exploration projects • current rate of per capita oil consumption very low by international standards	• moderate oil dependence (25% of primary energy) • high oil import dependency (more than 70% of crude and petroleum fuels) • risk of dependence on Iran & Saudi Arabia for 30% of crude oil imports • delays in building strategic stocks • increasing demand for petroleum products • low penetration of international oil companies	• possible interruptions to supply of crude oil and refined fuel imports • possible disruptions to supply of coal to power stations • upward pressure on electricity prices • increased cost of renewable energy infrastructure
Transport	• extensive and growing road network • rail network connects major urban centres • several major ports to facilitate cheaper transport and trade (for coastal settlements) • rapid transit systems in top 3 cities • potential for greater bicycle and cycle rickshaw use • development of rapid transit systems in all mega-cities (more than 4 million) • development of rail-based dedicated freight corridors	• extremely high dependence on petroleum fuels (95%) • very high reliance on roads for freight and passenger transport • inadequate public transport • low growth rate of rail infrastructure • growing reliance on roadways and airways for freight and passenger mobility • large investments in airport upgrades	• rising costs of passenger & freight transport • constrained mobility of passengers • rising costs of road maintenance • possible interruptions to freight logistics
Agriculture	• large number of small farmers represent 80% of agricultural land: strength in diversity • self-sufficient in most agricultural commodities, including rice and wheat • stupendous growth in food production from 1980-2010	• high petroleum dependence (40% in 2008) • growing reliance on electricity and oil • increasing mechanisation of the sector • growing share of diesel and fertilisers in energy demand • output highly reliant upon monsoon rain • degrading soil quality	• rising input costs (diesel, fertilizers, and pesticides) • disruptions to farming activities • possible rise in farmer suicides • transport disruptions hamper the public distribution system of food to the poor

Subsystem	Strengths	Vulnerabilities	Impacts
Macro-economy	• reasonably well diversified economy • economy resilient to economic shocks • foreign debt relatively low (20%) • increasing diversification of trade to developing and neighbouring countries • high rate of domestic and household saving	• growing share of international trade makes economy vulnerable to rising transport costs • high rate of inflation since 2010 (9%), especially food price inflation • moderately large current account deficit (4% of GDP) • growing trade deficit due to large imports of oil (as well as gold and silver) • changing consumption patterns	• rising oil import bill and current account deficit • exchange rate depreciation • rising inflation • higher manufacturing costs • slowing economic growth
Society	• diverse and resilient culture • 65 years of stable democracy with a strong constitution • high social value placed on education • political focus on social justice and access to social services for the poor and vulnerable • relatively low degree of income inequality	• deep & widespread poverty • high degree of caste, gender and religion-based discrimination • high degree of food and nutrition insecurity • gaps in provision of social and food security • migration and immigration pressures	• rising cost of living • rising rates of poverty, inequality and discrimination • deteriorating household food security • constrained mobility • increasing social tensions & strife

7. References

AAI. 2012. About AAI. New Delhi: Airports Authority of India, Government of India. [Online]. Available: http://www.india.gov.in/outerwin.php?id=http://www.airportsindia.org.in/

Bhanumurthy, N. R., Das, S. andBose, S. 2012. Oil Price Shock, Pass-through Policy and its Impact on India. Working Paper No. 2012-99. March 2012. New Delhi: National Institute of Public Finance and Policy.

BP. 2012. Statistical Review of World Energy 2012. London: BP plc.

BSCAA. 2011. Background Note: India. Washington DC: Bureau of South and Central Asian Affairs, United States Department of State. April 17, 2012. [Online] Available: http://www.state.gov/r/pa/ei/bgn/3454.htm

Chaturvedi, S. 2012. *Coal India forecasts sluggish output growth*. New York: The Wall Street Journal, US Edition. November 15, 2012. [Online]. Available: http://online.wsj.com/article/SB10001424127887324556304578120371605548866.html?mod=googlenews_wsj

DES. 2011. Agricultural Statistics at a Glance. Directorate of Economics and Statistics. New Delhi: Government of India. [Online]. Available: http://eands.dacnet.nic.in/latest_2006.htm

DOC. 2012. System on Foreign Trade Performance Analysis. New Delhi: Department of Commerce, Ministry of Commerce and Industry, Government of India. [Online]. Available: http://commerce.nic.in/ftpa/default.asp

De la Rue du Can, S., Letschert, V., McNeil, M., Zhou, N. and Sathaye, J. 2009a. Residential and transport energy use in India: past trend and future outlook. Ernest Orlando Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division. January, 2009

De la Rue du Can, S., McNeil, M. and Sathaye, J. 2009b. India Energy Outlook: End Use Demand in India to 2020. Ernest Orlando Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division. January, 2009

DGFT. 2011. Annual Report 2010-11. New Delhi: Directorate General of Foreign Trade, Ministry of Commerce and Industry, Government of India.

Dutta, S. 2012. *India's strategic oil stockpile plan delayed by a year*. New Delhi: The Times of India. October 16, 2012. [Online]. Available: http://timesofindia.indiatimes.com/business/india-business/Indias-strategic-oil-stockpile-plan-delayed-by-a-year/articleshow/16841571.cms

EIA. 2011. India Country Analysis Brief. Washington, D.C.: US Energy Information Administration.

EIA. 2012. International Energy Statistics. US Energy Information Administration. [Online]. Available: http://www.eia.doe.gov/emeu/international/contents.html

FAO. 2011. India and FAO, Achievements and Success Stories. Rome: Food and Agriculture Organisation of the United Nations. March 2011.

FAOSTAT. 2012. Food and Agriculture Organisation Statistical Database. Food and Agriculture Organisation of the United Nations. [Online]. Available: http://faostat.fao.org/

Fischer-Kowalski, M. & Swilling, M. 2011. Decoupling Natural Resource use and Environmental Impacts from Economic Growth. Paris: United Nations Environment Programme.

Ghate, A. & Sundar, S. 2011. Transport and Energy: The Indian Perspective. *Transport Moving to Climate Intelligence: New Chances for Controlling Climate Impacts of Transport after the Economic Crisis*. Edited by: Prof. Werner Rothengatter, Prof. Yoshitsugu Hayashi, and Prof. Wolfgang Schade. Part 4, pp.147-159. Springer

IBNLive. 2012. *India's poverty line now lowered to less than Rs28 per day*. [Online] Available: http://ibnlive.in.com/news/indias-poverty-line-now-lowered-to-rs-28-per-day/240737-3.html

IEA. 2012. Statistics and Balances. International Energy Agency. [Online]. Available: http://www.iea.org/stats/index.asp

IIHS. 2011. Urban India 2011: Evidence. New Delhi: Indian Institute for Human Settlements. November 22, 2011

IMF. 2012. International Financial Statistics. Washington, D.C.: International Monetary Fund.

IPA. 2012. The Profile. New Delhi: Indian Ports Association. [Online]. Available: http://ipa.nic.in

Jha, G. K., Pal, S. and Singh, A. 2012. Changing Energy-Use Pattern and the Demand Projection for Indian Agriculture. *Agricultural Economics Research Review*, 25(1) January-June 2012, 61-68.

Mandal, K., Bhattacharyya, I. and Bhoi, B.B. 2012. Is the oil-price through in India any different? *Journal of Policy Modeling (2012),* http://dx.doi.org/10.1016/j.jpolmod.2012.06.001

Menon-Sen, K. (2010). Delhi and CWG2010: The Games Behind the Games. *The Journal of Asian Studies*. Vol. 69, No. 3 (August) 2010: 1–5

Mishra, R. (2012). *India to make 45% of Iran oil payments in rupees*. New Delhi: The Hindu Business Line. February 7, 2012. [Online]. Available: http://www.thehindubusinessline.com/industry-and-economy/economy/article2868666.ece

MOF. 2012. Economic Survey 2011-12. New Delhi: Ministry of Finance, Government of India.

MOR. 2009. Indian Railways - VISION 2020. New Delhi: Ministry of Railways, Government of India.

MOR. 2011. Indian Railways Yearbook 2010-11. New Delhi: Ministry of Railways, Government of India. [Online]. Available: http://www.indianrailways.gov.in/railwayboard/uploads/directorate/stat_econ/yearbook10-11/Year_book_10-11_eng.pdf

MORD. 2011. National Social Assistance Programme (NSAP). New Delhi: Ministry of Rural Development, Government of India. [Online] Available: http://nsap.nic.in/nsap/NSAP-%20About%20us.pdf

MORTH. 2012a. Basic Road Statistics of India, 2008-09, 2009-10 & 2010-11. New Delhi: Ministry of Road Transport and Highways, Transport Research Wing, Government of India. August 2012. [Online]. Available: http://morth.nic.in/showfile.asp?lid=839

MORTH. 2012b. Road Transport Year Book, 2009-10 & 2010-11. New Delhi: Ministry of Road Transport and Highways, Transport Research Wing, Government of India. July 2012.

MOS. 2012. Major and Minor Ports. New Delhi: Ministry of Shipping, Government of India. [Online]. Available: http://www.shipping.nic.in/index1.php?lang=1&level=0&linkid=16&lid=64

MOSPI. 2012. Energy Statistics 2012. New Delhi: Central Statistics Office, Ministry of Statistics and Programme Implementation, Government of India. www.mospi.gov.in

MPNG. 2011. Basic Energy Statistics 2011. New Delhi: Ministry of Petroleum and Natural Gas, Economics Division, Government of India.

NHAI. 2012. National Highways Development Project (NHDP). New Delhi: National Highways Authority of India. [Online]. Available: http://www.nhai.org/WHATITIS.asp

NPOI. 2012. General Overview, Agriculture. New Delhi: National Portal of India, Department of Electronics and Information Technology, Ministry of Communications and Information Technology, Government of India. [Online]. Available: http://india.gov.in/sectors/agriculture/index.php?id=2

NSSO. 2011. Level and Pattern of Consumer Expenditure 2009-2010. New Delhi: National Sample Survey Office, National Statistical Organisation, Ministry of Statistics and Programme Implementation, Government of India.

OIFC. 2012. Ports in India. Haryana: Overseas Indian Facilitation Centre. September 28, 2012. [Online]. Available: http://www.oifc.in/sectors/infrastructure/ports

ONGC. 2012. Annual Report: OVL-2011-12 (ONGC Videsh Limited). New Delhi: Oil and Natural Gas Corporation Limited. September 11, 2012. [Online]. Available: http://www.ongcindia.com/%5Cdownload%5CAnnualreports%5COVL_AR%202011-12.pdf

ORGI. 2011. Census of India 2011. New Delhi: Office of the Registrar General and Census Commissioner, Ministry of Home Affairs, Government of India. [Online]. Available: http://censusindia.gov.in/2011census/censusinfodashboard/index.html

Pandey, M.M. 2009. Indian Agriculture – An Introduction. Submission to the Fourth Session of the Technical Committee of APCAEM. 10-12 February, 2009, Chiang Rai, Thailand.

Pangotra, P. & Shukla, P.R. 2012. Infrastructure for Low Carbon Transport in India, a Case Study of the Delhi-Mumbai Dedicated Freight Corridor. Ahmedabad: Indian Institute for Management

Planning Commission. 2007a. Volume III: Agriculture, Rural Development, Industry, Services and Physical Infrastructure, Eleventh Five Year Plan. New Delhi: Planning Commission of India

Planning Commission. 2007b. Volume II: Social Sector, Eleventh Five Year Plan. New Delhi: Planning Commission of India

Planning Commission. 2007c. Volume I: Inclusive Growth, Eleventh Five Year Plan. New Delhi: Planning Commission of India

Planning Commission. 2012. Recommendations of Working Group on Urban Transport for the 12th Five Year Plan. New Delhi: Planning Commission of India. [Online]. Available: http://planningcommission.nic.in/aboutus/committee/wrkgrp12/hud/wg_%20urban%20Transport.pdf

Rao, N., Sant, G. and Rajan, S.C. 2009. An Overview of Indian Energy Trends: Low Carbon Growth and Development Challenges. Pune, India: Prayas, Energy Group.

RBI. 2012a. Handbook of Statistics on India Economy 2011-12. Mumbai: Reserve Bank of India. [Online]. Available: http://www.rbi.org.in/scripts/AnnualPublications.aspx?head=Handbook%20of%20Statistics%20on%20Indian%20Economy

RBI. 2012b. Annual Report 2011-12. Mumbai: Reserve Bank of India. [Online]. Available: http://www.rbi.org.in/scripts/AnnualReportPublications.aspx?Id=1039 and http://www.rbi.org.in/scripts/AnnualReportPublications.aspx?Id=1052

RITES. 2009. Total Transport System Study on Traffic Flows and Modal Costs. New Delhi: Planning Commission of India.

Sihag, A. R., Chatterji, S. and Khetan, A. 2002. Vulnerability of the Indian economy to tensions in the Middle East: impacts and responses. *Pacific and Asian Journal of Energy* 12(1): 7-22.

Singh, S. K. 2006a. The demand for road-based passenger mobility in India: 1950-2030 and relevance for developing and developed countries. *European Journal of Transport and Infrastructure Research*, 6, no. 3 (2006), pp. 247-274

Singh, S. K. 2006b. Future Mobility in India: Implications for Energy Demand And CO2 Emission. *Transport Policy* 2006, September, 398-412.

Sinha, U. K. and Dadwal, S. R. 2005. *Strategic Analysis: Equity Oil and India's Energy Security*. Institute for Defence Studies and Analyses. Volume 25, Issue 3, Commentaries. [Online]. Available: http://www.idsa.in/strategicanalysis/EquityOilandIndiasEnergySecurity_srdadwal,%20uksinha_0705

Seethalakshmi, S. 2011. *Indian cities can't do without a Metro*. Bangalore: Times of India. October 20, 2011, 01.47AM IST. [Online]. Available: http://timesofindia.indiatimes.com/city/bangalore/Indian-cities-cant-do-without-a-Metro/articleshow/10421213.cms

TERI, 2007. TERI Energy Data Directory and Yearbook, 2006-07. New Delhi: Tata Energy and Resources Institute.

TERI, 2009. National Energy Map for India: Technology Vision 2030. New Delhi: Tata Energy and Resources Institute.

Thomson, W. 2012. *India's Food Security Problem*. Indian Decade? Inside Asia's other giant. Tokyo: The Diplomat, April 2, 2012. [Online]. Available: http://thediplomat.com/indian-decade/2012/04/02/india%E2%80%99s-food-security-problem/

The Hindu. 2012. *Moily promises quick decisions*. Special Correspondent, Economy, Business, The Hindu. [Online]. Available: http://www.thehindu.com/business/Economy/moily-promises-quick-decisions/article4043112.ece

UN-HABITAT, 2011. The State of Asian Cities 2010/11. Nairobi: UN-HABITAT features, UN-HABITAT. http://www.unhabitat.org/documents/WHD10/EN/Asia_Press_kits/CaseStudies7.pdf

UNICEF. 2012. India Statistics. [Online] Available: http://www.unicef.org/infobycountry/india_statistics.html [accessed 21/11/2012]

United Nations. 2012. Cartographic Section. [Online]. Available: http://www.un.org/Depts/Cartographic/english/htmain.htm (accessed 15 November 2012)

Wakeford, J.J. 2012. Implications of global oil depletion for South Africa: vulnerabilities, impacts and transition to sustainability. PhD Dissertation, Stellenbosch University, South Africa.

Wakeford, J.J. & de Wit, M. 2012. Oil Shock Mitigation Strategies for Developing Countries. Draft Report compiled for the United Kingdom Department for International Development. 23 November 2012.

World Bank. 2012. World Development Indicators. [Online] Available: http://databank.worldbank.org/ddp/home.do [accessed 1/10/2012]

Zhou, N and McNeil, M. 2009. Assessment of historic trend in mobility and energy use in India transportation sector using bottom-up approach. Ernest Orlando Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division. May, 2009