OIL SHOCK MITIGATION STRATEGIES

FOR DEVELOPING COUNTRIES

JUNE 2013

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Sustainability Institute and School of Public Leadership
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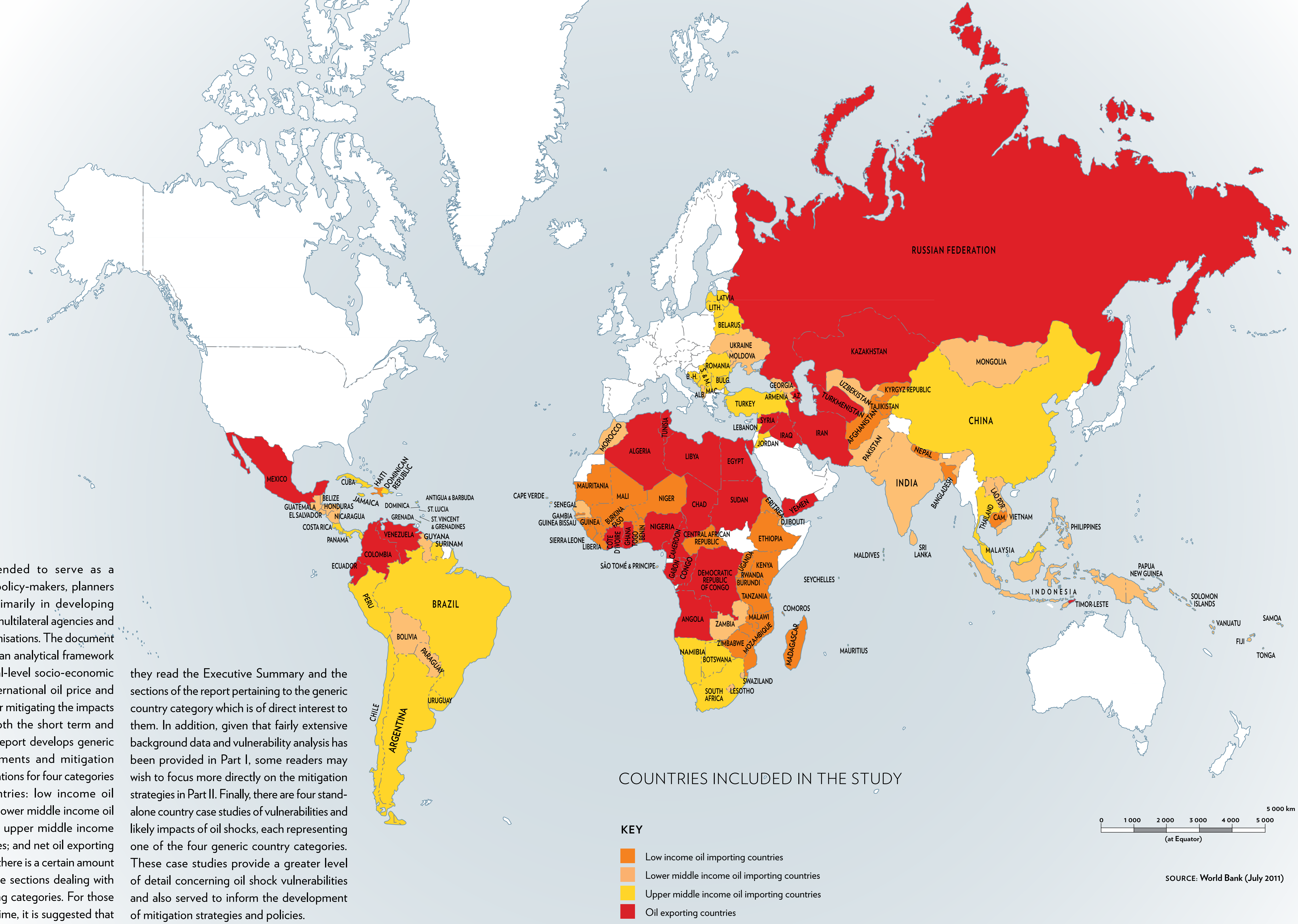
Note to Readers

This report is intended to serve as a reference work for policy-makers, planners and researchers, primarily in developing countries but also in multilateral agencies and international aid organisations. The document presents and applies an analytical framework for assessing national-level socio-economic vulnerabilities to international oil price and supply shocks, and for mitigating the impacts of such shocks in both the short term and the long term. The report develops generic vulnerability assessments and mitigation strategy recommendations for four categories of developing countries: low income oil importing countries; lower middle income oil importing countries; upper middle income oil importing countries; and net oil exporting countries. By design, there is a certain amount of overlap among the sections dealing with the three oil importing categories. For those readers with limited time, it is suggested that they read the Executive Summary and the sections of the report pertaining to the generic country category which is of direct interest to them. In addition, given that fairly extensive background data and vulnerability analysis has been provided in Part I, some readers may wish to focus more directly on the mitigation strategies in Part II. Finally, there are four stand-alone country case studies of vulnerabilities and likely impacts of oil shocks, each representing one of the four generic country categories. These case studies provide a greater level of detail concerning oil shock vulnerabilities and also served to inform the development of mitigation strategies and policies.



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Contents

Abbreviations

AfDB	African Development Bank
BEV	Battery Electric Vehicle
CHP	Combined Heat and Power
CNG	Compressed Natural Gas
CSP	Concentrated Solar Power
CTL	Coal-to-liquids
EIA	Energy Information Administration
ELF	Ethno-linguistic Fractionalization
EROI	Energy Return on Investment
GDP	Gross Domestic Product
GFCF	Gross Fixed Capital Formation
GNI	Gross National Income
FAO	Food and Agriculture Organisation
FCS	Fragile and Conflict Affected States
GCV	Grid-connected Vehicle
GTL	Gas-to-liquids
HEV	Hybrid Electric Vehicle
ICE	Internal Combustion Engine
ICT	Information and Communication Technology
IEA	International Energy Agency
IMF	International Monetary Fund
LED	Local Economic Development
LIC	Low Income Country
LMIC	Lower Middle Income Country
MENA	Middle East and North Africa
NMT	Non-motorised Transport
OEC	Oil Exporting Country
OECD	Organisation for Economic Cooperation and Development
R&D	Research and Development
RE	Renewable Energy
SIDS	Small Island Developing States
SMME	Small, Medium and Micro-enterprises
SPR	Strategic Petroleum Reserve
SSA	Sub-Saharan Africa
SWHs	Solar Water Heaters
TEQs	Tradable Energy Quotas
TPES	Total Primary Energy Supply
UMIC	Upper Middle Income Country
USGS	United States Geological Survey
WFP	World Food Programme
WTO	World Trade Organisation

Units of Measurement

bpd	barrels per day
kbpd	thousand barrels per day
bn	billion
GW	gigawatts
GWth	gigawatts thermal hours
kg	kilograms
mbpd	million barrels per day
MW	megawatts
r/p	reserve to production ratio
tcf	trillion cubic feet
TWh	terawatt hours

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EXECUTIVE SUMMARY

Background and Motivation

Oil is the master energy resource commodity fuelling the world economy, providing 33% of global primary energy supply, meeting over 40% of final energy demand, supplying 95% of the energy fuelling global transport systems, and providing feedstock for the diverse petrochemicals industry (IEA, 2012b). Since the Second World War, growth in the world economy has been strongly correlated with growth in oil consumption (Hirsch, 2008). The International Energy Agency (IEA, 2012a) has forecast that global demand for oil could grow by 14% between 2010 and 2035, with all of the net additional demand projected to come from emerging economies.

However, there are both short-term and long-term threats to the supply of oil. The major near-term threats to supply are: geopolitical and civil tensions in oil exporting regions and countries; certain technical production complexities; and extreme weather events in oil producing areas. Historically, major global oil price shocks, involving a doubling or more of prices, have been triggered by supply disruptions amounting to just a few million barrels per day. In the longer term, the historical trend of increasing supplies of oil cannot continue indefinitely since oil is a finite and depleting resource. Conventional crude oil production – oil derived using typical extraction and refining techniques – has been essentially flat at around 74 million barrels per day (mbpd) since 2005 and the IEA (2012a) states that it probably will not exceed the peak reached in 2008. Rising unconventional oil production has come with substantially higher economic and environmental costs and has not supported previous oil supply growth rates. Crucially for net importing countries, world oil exports have been on a slightly declining trend since 2005. Moreover, the quality of available oil – as measured for example in the energy return on (energy) investments for world oil – is declining as the frontier for new oil production has moved into more remote areas such as deep off-shore wells, polar regions and unconventional oil sources including tar sands and shale oil.

These supply-side factors, together with burgeoning demand in emerging markets, suggests that there will be a continued risk of oil price and supply shocks in the foreseeable future. Recent modelling by researchers at the International Monetary Fund (IMF) and the Organisation for Economic Cooperation and Development (OECD) suggests that oil prices could rise to between $150-$250 per barrel by 2020 and even higher after that, with substantial short-term fluctuations around this trend.

Developing countries are especially vulnerable to oil shocks as many have a relatively high oil intensity of economic growth, while the least developed countries often lack the resources to cope effectively with external economic shocks. The International Energy Agency advises its high-income member countries on appropriate responses to oil shocks and coordinates their actions, but no similar agency or set of mitigation plans exists for developing countries.

Aims and Methodology

The main aims of the project are to provide developing countries with a systematic framework and methodology for identifying the major vulnerabilities to and likely socioeconomic impacts of oil price and supply shocks, and for devising national oil shock mitigation strategies in order to be able to respond proactively to such threats. The analysis is based on a combination of empirical data drawn from various international agencies, together with existing research concerning oil security and oil shock vulnerabilities amongst developing countries. The analysis addresses vulnerabilities and mitigation of oil shocks in a wide range of socioeconomic areas, including the energy system, transport and mobility, agriculture and food security, the macro-economy, and social concerns such as poverty and inequality, settlement patterns and social cohesion. Our emphasis in this report is mainly on the various *energy* uses of oil, since the non-energy uses of oil (e.g. as feedstock for petrochemical products and lubricants) constitute a relatively minor share (approximately 16%) of global oil consumption (IEA, 2012a) and because it is generally more difficult to find substitutes for these applications. To enhance the tractability of the analysis, developing countries were divided into four generic categories, namely: low income oil importing countries, lower-middle income oil importing countries, upper-middle income oil importing countries, and oil exporting countries.

Vulnerabilities and Impacts

Vulnerability to oil shocks at a country level depends on numerous energy, economic and social characteristics, including:

- expenditure on oil as a proportion of GDP;
- the ratio of oil imports to total oil consumption (oil import dependency);
- the ratio of oil consumption to total energy consumption (oil resource dependency);
- the energy intensity of economic activity;
- the proportion of electricity generated from oil;
- the level of industrialisation, including the degree to which the production and distribution of food is mechanised;
- the prevalence of motor vehicles and the extent of urbanisation; and
- rates of poverty and income inequality.

The data in Table A summarise some of the key socioeconomic indicators across the four generic country categories. Reliance on oil for electricity generation is higher on average in LICs and OECs than in the other categories. As expected, the prevalence of motor vehicles and the proportion of the population living in urban areas increase with income level, while the rate of poverty declines dramatically.

The empirical evidence shows that the following generalisations hold across the three net oil importing country categories (see Table B):

- per capita oil consumption rises with income;
- the contribution of agriculture to GDP falls as income rises;
- the contribution of industry to GDP initially rises as countries progress from low income to lower-middle income level, but then stabilises as income rises further; and
- the contribution of service sectors to GDP rises as income per capita rises.

As the OEC category includes low, lower middle and upper middle income countries, it is not surprising that the average economic indicators for the OEC group fall within the range exhibited by the three oil importer groups.

Table A: Summary of oil and socioeconomic indicators for the four generic country categories

Indicator	Electricity production from oil	Motor vehicles	Urban population	GINI coefficient	Poverty rate at $2 a day
Units	% of total	per 1,000 people	% of total	Index	% of population
Year	2009	2009	2010	2009	2010
LIC average	32	19	30	40	71
LMIC average	21	75	44	42	36
UMIC average	19	197	62	43	8
OEC average	26	92	57	40	33
Correlation with GNI per capita (importers only)	-0.17	0.81	0.65	0.17	-0.76

SOURCE: Own calculations based on EIA (2012) and World Bank (2012)

Average oil vulnerability indicators for oil importers are presented in Table C. Interestingly, the average percentage of GDP spent on oil is virtually the same across the three income categories. However, mean oil import dependence falls slightly as income level rises, although this discrepancy diminished between 2008 and 2011. Average oil intensity is higher in LICs (71%) than in the other two categories (59% each), but it must be emphasized that this relates only to the proportion of modern energy carriers provided by oil; most LICs rely heavily on traditional biomass fuels, which are not included in these oil intensity calculations. Finally, average energy intensity is much the same in LICs and UMICs, but nearly 50% higher amongst the LMICs. This makes sense, since as countries develop they generally move from specialisation in agriculture, to energy-intensive heavy industries, to higher-technology industries, to services.

Despite the foregoing generalisations, however, the data also reveal a high degree of cross-country heterogeneity in the main oil vulnerability indicators. First, there is no discernible relationship between oil vulnerability (expenditure on oil as a percentage of GDP) and gross national income (GNI) per capita (see Figure A). Second, the degree of oil import dependence varies greatly across net oil importing developing countries (see Figure B); the vast majority of countries rely on imports to meet more than half of their oil consumption, and some 66 out of the sample of 105 countries are completely reliant on imports for their oil supplies. Third, the degree of oil intensity (i.e., the extent to which a country relies on oil to meet its modern energy needs) also ranges widely across countries, and with no particular association with income level (see Figure C).

Table B: Summary of economic indicators for the generic country categories

Indicator	GNI per capita	Oil consumption per capita	Agriculture, value added	Industry, value added	Services, etc., value added
Units	current US$	barrels/yr	% of GDP	% of GDP	% of GDP
Year	2011	2011	2010	2010	2010
LIC average	574	0.5	31	22	47
LMIC average	2 378	2.4	17	29	54
UMIC average	7 693	7.3	7	28	66
OEC average	4 229	4.5	13	44	43
Correlation with GNI per capita (importers only)		0.67	-0.69	0.08	0.59

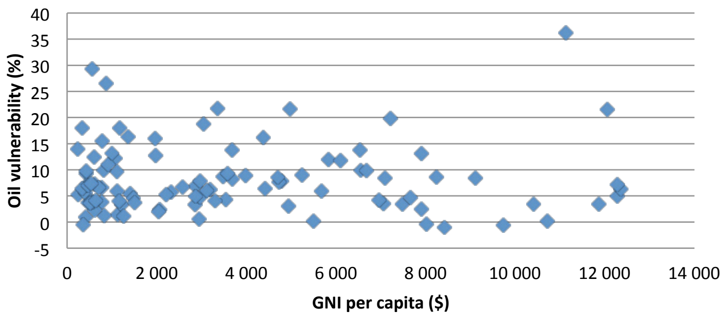
SOURCE: Own calculations based on EIA (2012) and World Bank (2012)

Table C: Summary of oil vulnerability indicators for net oil importers

Indicator	Oil vulnerability	Oil import dependence	Oil vulnerability	Oil import dependence	Oil intensity	Energy intensity
Description	Oil expenditure/ GDP	Oil imports/ oil use	Oil expenditure/ GDP	Oil imports/ oil use	Oil use/ energy use	Energy use/ GDP
Units	%	%	%	%	%	Btu/$
Year	2011	2011	2008	2008	2008	2008
LIC average	8	95	8	98	71	9 685
LMIC average	7	83	8	82	59	14 152
UMIC average	8	79	7	77	59	9 573
Average for all	8	85	8	85	63	11 220

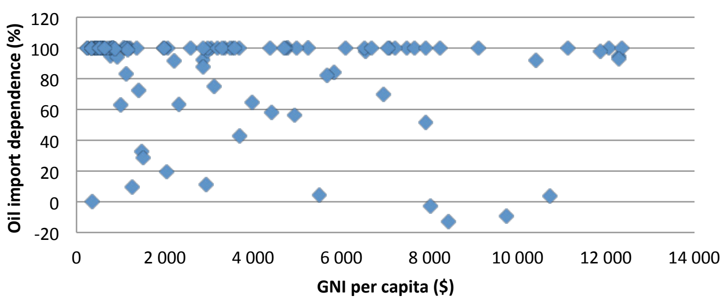
SOURCE: Own calculations based on EIA (2012) and World Bank (2012)

Figure A: Oil vulnerability and gross national income per capita in oil importing countries



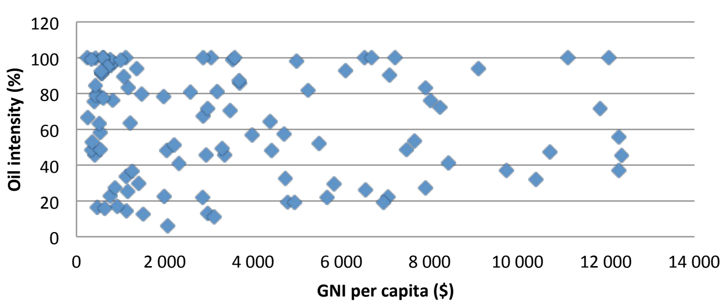
SOURCE: Own calculations based on EIA (2012) and World Bank (2012)

Figure B: Oil import dependence and GNI per capita in oil importing countries



SOURCE: Own calculations based on EIA (2012) and World Bank (2012)

Figure C: Oil intensity and GNI per capita in oil importing countries



SOURCE: Own calculations based on EIA (2012) and World Bank (2012)

Statistical regression analysis revealed that the variation in oil consumption per capita is best explained by income per capita, average diesel and petrol prices, the number of motor vehicles per 1,000 people, and the percentage of electricity produced from oil. On the other hand, the percentage contribution of industry to GDP, the urbanisation rate, and the degree of oil import dependency were not significant determinants of oil consumption. Based on the historical record, it appears that developing countries have been considerably less susceptible to oil price shocks than the industrialised countries, which generally have much higher rates of oil consumption per person.

Net oil exporting developing countries are a heterogeneous group with various levels of socioeconomic development and different types of vulnerabilities. In terms of their socioeconomic characteristics the evidence for oil exports improving socioeconomic conditions is mixed. On the one hand, there is some evidence to suggest that oil production is linked to lower poverty levels and greater development. On the other hand, higher oil production has not, by and large, reduced unemployment rates. This may in part be due to reduction in employment in non-oil sectors. In terms of oil dependencies and vulnerabilities, a number of African countries and a small island developing states are heavily reliant on oil exports and revenues, including: Congo, Sudan, Angola, Nigeria and Timor-Leste. Other more developed economies are heavily reliant on oil for domestic consumption such Iraq, Iran, Turkmenistan, Yemen, Libya and Venezuela. In most oil exporting countries, state fragility (as measured by an index developed by Marshall and Cole, 2010) has lessened between 2000 and 2010, although there remains very high state fragility in Sudan, DRC, Chad and Cote d'Ivoire. In terms of the likely impacts of oil shocks, there is some, but case specific, evidence for the 'resource curse' amongst oil exporting economies, with appreciating exchange rates ('Dutch disease'), adverse impacts on manufacturing and non-tradable goods ('crowding out'), weak institutions and governance as well as symptoms of anarchy and even civil war. The discovery of oil increases the risk of and has also led to secessionist violence in a number of countries.

A summary of the socioeconomic characteristics, oil dependencies, and likely impacts of oil shocks across the four generic categories is provided in Table D.

Table D: Summary of vulnerabilities and impacts for the four generic country categories

COUNTRY CATEGORY	SOCIOECONOMIC CHARACTERISTICS	OIL DEPENDENCIES & VULNERABILITIES	LIKELY IMPACTS OF OIL PRICE SHOCKS
Low income	▪ undiversified economies with large agriculture sector ▪ high degree of reliance on world trade for both commodity exports and manufactured imports ▪ extremely high rates of poverty and undernourishment ▪ moderate to large current account deficits and external debt/GDP ratios	▪ very low oil consumption per person ▪ moderately high oil vulnerability ▪ moderate oil resource dependency ▪ very high oil import intensity	▪ deteriorating balance of payments and terms of trade ▪ decline in production & GDP growth ▪ rise in producer and consumer price inflation ▪ broadening and deepening of poverty and food insecurity ▪ possible social upheaval
Lower-middle income	▪ large contribution of energy-intensive industry ▪ comparatively low levels of foreign reserves in relation to external debt ▪ large current account deficits and a high level of dependence on international trade ▪ moderately high incidence of poverty ▪ large urban poor populations	▪ low levels of oil consumption per person ▪ moderately high oil vulnerability ▪ very high oil resource dependency ▪ high oil import intensity ▪ transport infrastructure highly reliant on oil	▪ growing current account deficit ▪ slowing GDP growth and employment creation ▪ rise in price inflation, especially for transport and food items ▪ increasing rates of poverty and inequality ▪ growing food insecurity, possibly undermining social cohesion
Upper-middle income	▪ relatively extensive trade and financial integration with high income countries ▪ moderate to large current account deficits and external debt to GDP ratios ▪ relatively high average urbanisation rate and prevalence of motor vehicles	▪ moderate oil consumption per person ▪ moderately high oil vulnerability ▪ very high oil resource dependency ▪ high oil import intensity ▪ transport & settlement infrastructure heavily dependent on oil	▪ growing current account deficit and financial account outflows ▪ exchange rate volatility ▪ slowing GDP growth and job losses in vulnerable sectors ▪ rising cost of living and constrained mobility for many households ▪ crises in critical systems if oil shortages arise
Oil exporters	▪ highly variable incidence of poverty, inequality and unemployment ▪ evidence for oil exports improving socioeconomic conditions is mixed: there is some evidence to suggest that oil production is linked to lower poverty levels and greater development; ▪ but higher oil production has not, by and large, reduced unemployment rates, possibly due in part to reduction in employment in non-oil sectors	▪ several African countries and small island development states are heavily reliant on oil for export and government revenues, including: Congo, Sudan, Angola, Nigeria and Timor-Leste ▪ other more developed economies are heavily reliant on oil for domestic consumption: e.g. Iraq, Iran, Turkmenistan, Yemen, Libya and Venezuela ▪ risk of declining oil revenues in countries whose net oil exports are declining due to rising consumption and/or depletion, although mitigated by rising oil prices	▪ macroeconomic instability arising from oil price volatility ▪ there is some, but case specific, evidence for the 'resource curse' amongst oil exporting economies, with appreciating exchange rates ('Dutch disease'), adverse impacts on manufacturing and non-tradables ('crowding out'), weak institutions and governance as well as symptoms of anarchy and even civil war ▪ discovery of oil increases the risk of, and has also led to, secessionist violence in a number of countries ▪ negative socioeconomic impacts of rising world prices for food and manufactured goods

Three special groups of net oil importing countries that cross-cut the income categories were found to have particular vulnerabilities to oil shocks, namely landlocked countries, small island developing states, and fragile states (see Table D).

Table D: Summary of vulnerabilities in special country categories

LANDLOCKED COUNTRIES	SMALL ISLAND DEVELOPING STATES	FRAGILE STATES
▪ little or no oil refining capacity ▪ end of the fuel supply chain ▪ high transport costs for fuel & other traded goods ▪ high average fuel prices	▪ very high oil resource dependency ▪ extremely high dependence on oil for electricity ▪ little or no oil refining capacity ▪ end of the fuel supply chain ▪ lack of economies of scale ▪ little geopolitical power	▪ weak state capacity ▪ low state legitimacy ▪ prone to violent conflict ▪ infrastructure vulnerable to interference

Despite the generalisations made above, one of the key findings from the empirical analysis is that there is a high degree of heterogeneity amongst the countries in each of the four generic categories. Therefore, each country will need to assess its particular strengths, weaknesses and oil shock vulnerabilities given its distinctive characteristics. This report has presented a methodology and framework for identifying such vulnerabilities on a case-by-case basis.

Mitigation Strategies

The extensive threats posed by growing global oil scarcity present a strong pragmatic rationale for proactive, government-led strategies, policies and measures to mitigate the harmful socioeconomic effects of international oil price and supply shocks. In the context of this report, mitigation is understood as actions taken *in advance* to lessen the negative impacts of *future* oil shocks, chiefly by reducing reliance on imported oil. (This usage of the term is somewhat different from that in the climate change literature, where mitigation refers to actions taken to reduce the likelihood of climate-related shocks occurring, while measures taken to respond to the impacts of climate change are termed adaption). Mitigation options were organised according to the following categories: the four generic country categories; five subsystems of the national socioeconomic system, namely energy, transport, agriculture, economy and society; short-term versus long-term strategies; and oil price shocks versus supply shocks.

Two concepts in particular underpin the mitigation strategies. First, since oil shocks are uncertain "external risks", which by their nature are complex and beyond the capacity of a single nation or organisation to manage and control, the most appropriate approach is to foster *resilience*. Following the World Economic Forum, a resilient country is understood as "one that has the capability to 1) adapt to changing contexts, 2) withstand sudden shocks and 3) recover to a desired equilibrium, either the previous one or a new one, while preserving the continuity of its operations" (WEF, 2013: 37). Second, the long-term mitigation of oil shocks is placed within the context of *societal transitions* from one type of socio-economic metabolism (in this case based on fossil fuels) to another (based on sustainable energy sources). This view posits that a socio-metabolic regime change will be driven either unintentionally as a consequence of resource depletion and/or pollution, or (ideally) as an intentional change chosen by society. Put differently, long-term mitigation of (cumulative) oil shocks provides a strong rationale for "green growth" strategies, over-and-above the usual (often climate-related) motivations. The concept of a *developmental state* is put forward as an appropriate institutional context for the formulation and implementation of oil shock mitigation strategies. A variety of *obstacles and constraints* on the implementation of the mitigation strategies are identified, including cultural-ideological, behavioural–psychological, social, political, institutional, economic and environmental factors. Each country will face its own particular combination and extent of these constraints.

Table F presents a summary of oil shock mitigation strategies for net oil importing countries. Many of the recommended strategies are common across all three income groups, although the emphasis will be somewhat different according to a particular country's level of development and socio-economic characteristics.

Table F: Summary of oil shock mitigation strategies for oil importing countries

SOCIOECONOMIC SUBSYSTEM	SHORT-TERM STRATEGIES, POLICIES & MEASURES	LONG-TERM STRATEGIES, POLICIES & MEASURES
Energy	Insulate the economy from excessive oil price volatility and physical supply shortages. ▪ introduce fuel price smoothing mechanism ▪ gradually phase out fuel subsidies, except possibly temporary, targeted subsidies for critical users ▪ ensure adequate strategic fuel inventories ▪ diversify sources of oil imports ▪ forge regional energy alliances with oil-importing and oil-exporting countries ▪ subscribe to a regional petroleum fund	Reduce reliance on imported oil through energy conservation & development of substitutes. ▪ foster energy conservation & efficiency with appropriate incentives & regulations ▪ phase out oil-fired power generation, replacing with alternatives ▪ promote energy efficient buildings and solar water heating ▪ boost development of energy substitutes, e.g. indigenous oil, gas, & renewable energy sources ▪ expand electricity grid ▪ promote use of solar cookers & efficient wood stoves ▪ promote decentralised micro-generation from renewable energy sources in rural areas
Transport	Prepare and implement fuel conservation and efficiency measures in the transport sector. ▪ introduce information campaign to promote fuel conservation & efficiency through eco-driving, good vehicle maintenance, car-pooling, flexible work schedules, telecommuting & Internet based shopping ▪ improve traffic management (e.g. reduce road speed limits, improve traffic flows to minimise vehicle idling) ▪ construct car-pool lanes in cities ▪ levy congestion charges in city centres ▪ implement selective driving bans in times of fuel shortage ▪ encourage modal shifts by increasing private vehicle taxes & licence fees and subsidising public transport	Invest in energy-efficient and electrified transport infrastructure to reduce oil dependence. ▪ regulate fuel economy standards for road vehicles ▪ use 'feebate' system and government procurement to promote uptake of efficient & alternative-fuel vehicles ▪ invest in cycle lanes & pedestrian walkways to support non-motorised transport in urban areas ▪ invest in public transport infrastructure, e.g. electrified railways, trams, electric bus rapid transit ▪ support bicycle & electric bicycle manufacture & distribution ▪ curtail investment in roads & airports ▪ implement 'user pays' principle for road upgrades
Agriculture & food	Improve resilience of food production and distribution system to oil price and supply shocks. ▪ possibly provide temporary diesel fuel subsidies for commercial farmers in planting & harvesting periods ▪ ensure sufficient fuel allocation for food distribution ▪ join a regional food security fund	Systematically reduce agriculture sector's reliance on oil and enhance food sovereignty. ▪ enhance food sovereignty by diversifying food production ▪ preserve remaining indigenous knowledge of traditional, oil-independent farming methods ▪ support knowledge & training in agro-ecological farming methods ▪ support development of bio-fertilisers and bio-pesticides ▪ encourage urban agriculture, e.g. by allowing mixed use zoning, allocating space for community gardens

continued overleaf

SOCIOECONOMIC SUBSYSTEM	SHORT-TERM STRATEGIES, POLICIES & MEASURES	LONG-TERM STRATEGIES, POLICIES & MEASURES
Economy	Insulate the macro-economy against excessive oil price volatility. ■ boost foreign exchange reserves to cushion impact of oil price spikes ■ avoid foreign and national debt accumulation ■ refrain from rapid interest rate hikes in response to transitory oil price spikes ■ maintain exchange rate flexibility to avoid rapid depletion of foreign exchange reserves	Plan to decouple economic development from oil consumption. ■ incorporate 'decoupling of development from oil' in economic policy & planning frameworks ■ reduce government budget and trade deficits as far as possible ■ use fiscal measures (selective taxes & subsidies) to promote green economy sectors & skill development ■ promote economic localisation to structurally reduce transport needs ■ reallocate funds from airports & roads to railways & telecommunications ■ practice wage restraint, especially in the public sector, to avoid wage-price spirals
Society	Maintain social cohesion in the face of fuel price spikes and/or shortages. ■ launch public awareness campaign to promote social cohesion during oil shock episodes ■ implement fuel rationing schemes that prioritise allocation to critical sectors & emergency services ■ improve poverty alleviation measures, e.g. job creation initiatives ■ forge regional alliances to enhance regional resilience and cohesiveness ■ sign an Oil Depletion Protocol	Plan socioeconomic and spatial development so as to reduce oil dependence. ■ build resilient communities through local economic development ■ foster rural development to slow the pace of urbanisation (mainly in LICs & LMICs) ■ plan sustainable human settlements, e.g. compact cities that are pedestrian- and cyclist-friendly ■ avoid urban sprawl ■ densify urban areas and allow mixed-use zoning to reduce transport needs

Figure D represents the short-term mitigation responses within a resilience framework, adapted from the World Economic Forum's *Global Risks* assessment (WEF, 2013).

Figure D: Measures to promote resilience to oil shocks

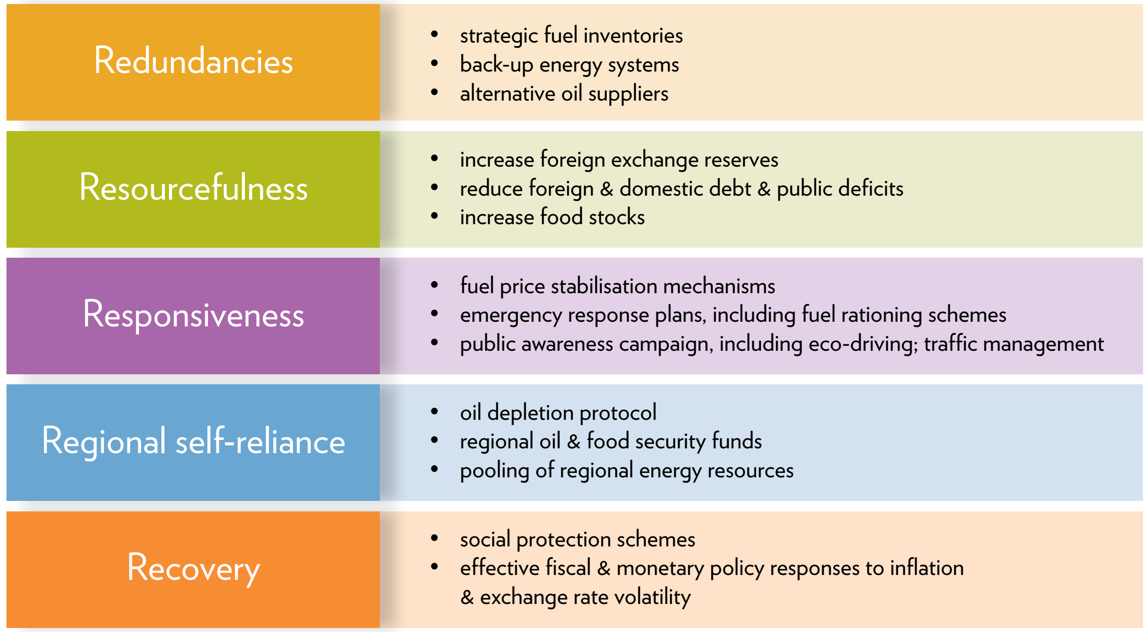
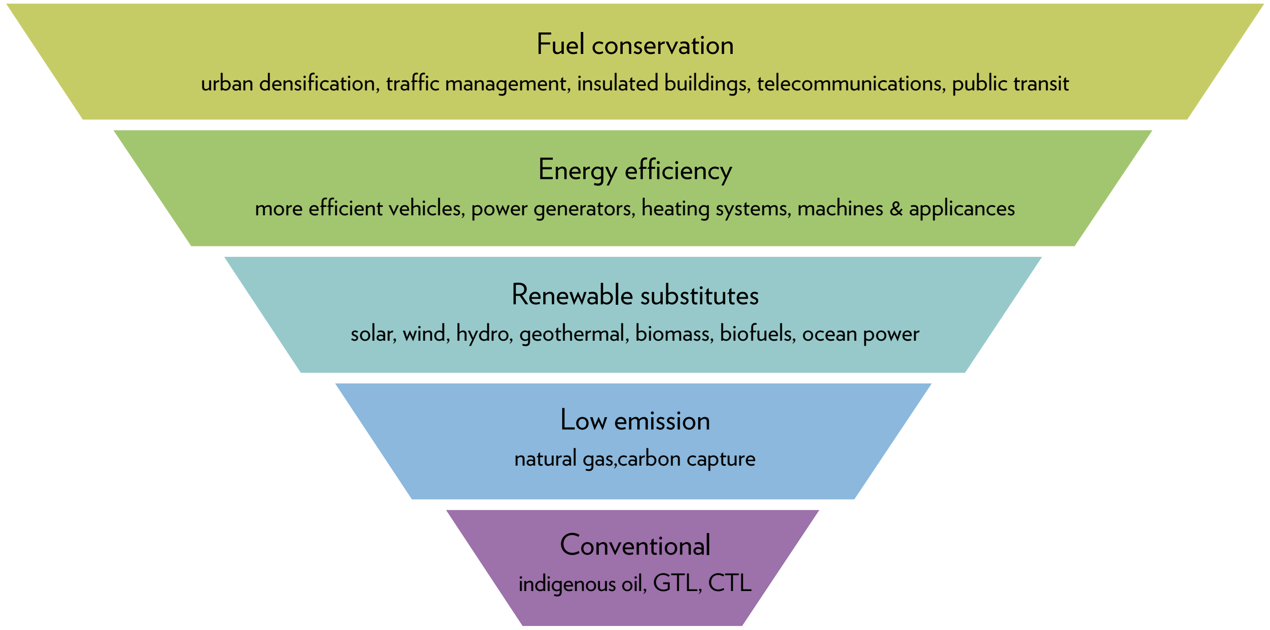


Figure E arranges the main long-term mitigation measures in a sustainability hierarchy, i.e. the measures are ranked from more sustainable to less sustainable.

Figure E: Hierarchy of sustainable long-term mitigation measures



The cloud of oil shock risks has a silver lining of **opportunity** in that rising oil prices can be used as a catalyst to stimulate a transition towards greater sustainability across a broad range of economic sectors. Above all, developing countries – especially those at earlier stages of development – have the opportunity to avoid some of the pitfalls of the oil-dependent development path that has been pursued by more advanced industrial economies. These pitfalls include lock-in to inefficient, oil-dependent infrastructures such as fleets of internal combustion engine vehicles and sprawling urban areas where mobility and accessibility rely heavily on private cars. By contrast, less developed nations have the opportunity to engage in 'technological leap-frogging' – skipping the oil-intensive phase of industrial development and instead adopting newer, more sustainable technologies and infrastructures from the outset. There are gains to be reaped through late-comer adoption of more sustainable technologies such as renewable energy and electrified mass transport systems. Given their greater financial resources and economic diversity compared to lower income nations, upper-middle income countries are arguably well placed to become leaders in the next wave of development.

The development of mitigation strategies for **net oil exporting countries** differs substantially from those for net importing nations. We again differentiate between oil *price* shocks, which emanate from the international market, and oil *supply* shocks, which in the exporter case are due to internal domestic factors. This part of the report examines the following more detailed questions for oil exporting countries as far as possible:

- How oil exporters can mitigate the impacts of oil production and exports on the macroeconomy (e.g. resource curse, lack of diversification, deindustrialisation) as well as on the environment?
- How oil exporters can mitigate the effects of oil price volatility, specifically in cases of high dependency on tax revenues from oil, impacts on government revenues and ability to invest, and the impacts on foreign exchange earnings?
- How to mitigate oil depletion while experiencing rising domestic consumption?
- How to mitigate conflicts over access to oil wealth?

The recommended mitigation strategies for oil exporting countries are summarised below.

Table F: Summary of oil shock mitigation strategies for oil exporting countries

THEME	MITIGATION OPTIONS
Exchange rates	■ There is a high risk that efforts to counter appreciating exchange rates are misplaced and counter-productive for oil exporters. ■ Without flexible exchange rates, money supply and inflation have started increasing in most oil exporting nations. ■ Long-term growth is positively associated with increasing oil income from oil exports.
Foreign reserves	■ The opportunity costs of holding large reserves tends to be high as returns in high grade-low risk instruments are low, placing increasing pressure on oil exporter governments to invest in the local economy. This raises the importance of an effective fiscal policy.
Diversification	■ Effective diversification of resource-rich countries can be achieved if there is macroeconomic stability underpinned by prudent spending, a reasonably open trade policy, and the active use of resource rents to increase the productivity of other exportable sectors. ■ A diversification in capital intensity within manufacturing will assist in cushioning the effects of oil shocks.
Environmental impacts	■ Effective environmental and health regulations, and adequate enforcement are a minimum prerequisite for mitigating the impacts of oil production. ■ A further environmental policy option is to reflect the full costs of oil extraction, transport and use in the price of fuels.
High dependence on oil exports	■ The main option for highly dependent oil exporting nations is to strengthen the institutional rules on how to deal with oil revenues and to develop other economic sectors that will help to broaden the tax base.
Government expenditure	■ Fiscal policy is of utmost importance for oil exporters in order to smooth surplus export receipts over time, invest them for future growth, and minimize wasteful spending. ■ Success factors include a strong concern for social stability and growth, a capable and engaged technocracy, and interests in the non-oil sectors able to act as agents of restraint. ■ The direct transfer of oil revenues to citizens is a mitigation option for oil rich countries to seriously consider.
Oil production and consumption	■ Governments should conduct thorough oil resource and reserve assessments and attempt to generate realistic forecasts of future oil production to serve as a rational basis for long-term economic planning and policies. ■ Mitigations options for dealing with rising domestic oil consumption would resort around increased oil use efficiencies and reductions of fuel subsidies, especially in the transport sector.
Civil conflict	■ A mitigation policy focussed on the large-scale redistribution of oil revenues to the broader population, for example via spending on economic infrastructure and social services, is a precondition for upholding internal peace and stability in oil exporting nations.
Foreign investment	■ Strong institutional and legal structures are needed to ensure an equitable share of oil revenues with foreign oil companies, an observation that is especially relevant to small and new oil exporting countries, and also especially relevant in a context of rising oil prices and thus revenue for net oil exporters.

Concluding Remarks

All net oil importing developing countries face similar economic impacts arising from global oil price shocks, such as: rising oil import bill and deteriorating balance of payments; rising rates of producer and consumer price inflation; slowing down of economic growth; and rising costs of living, deepening poverty and possibly inequality. Oil exporting countries face challenges relating to the resource curse, deindustrialisation, oil price and revenue volatility, civil conflict, and eventual depletion of oil reserves. Despite these generalisations, one of the key findings stemming from the empirical analysis is that there is a high degree of heterogeneity amongst the countries in each of the four generic categories, both in terms of their vulnerability profiles and their capacities to respond to oil shocks. Therefore, each country will need to assess its particular strengths, weaknesses and oil shock vulnerabilities given its distinctive characteristics.

The on-going depletion of relatively easily accessible and cheap oil reserves suggests that the rising trend in real oil prices observed over the past decade may well continue (albeit with heightened short-term price volatility). This clearly has significant implications for developing countries. For net oil importing nations, rising oil costs implies that the poorer countries may never to be able to afford the oil-intensive pattern of development that has been pursued by the industrialised and semi-industrialised world, while the semi-developed nations could find their current oil-based industrialisation path interrupted by shocks and increasingly unviable. For net oil exporting developing countries, rising average global oil costs will translate into windfall revenues as long as their rates of production and exports can be maintained, but face the prospect of greater oil price and revenue volatility in the medium term and declining net exports in the longer term. The challenge for these countries is to build strong institutions and to use their oil revenues for sustainable and equitable long-term development.

On a more positive note, developing countries face the prospect of exploiting new opportunities that will arise as oil and other fossil fuels continue to become more costly as a result of long-term depletion and growing demand, and as the need grows to reflect the true social and environmental costs of fossil fuels in their prices. Most importantly, they can aim to (partially) leapfrog the oil-intensive development path taken by the industrialised countries by investing in decentralised, renewable energy systems and more efficient transport systems, and by taking a less transport-intensive pathway through better spatial planning that prioritises non-motorised forms of mobility.

part 0.

INTRODUCTION

INTRODUCTION

0.

0.1 Background and Rationale

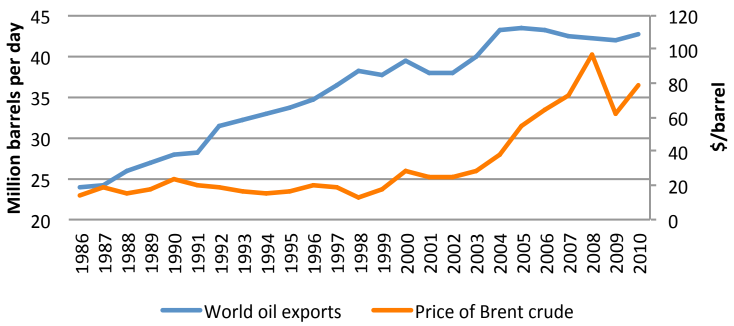
Oil is the master energy resource commodity fuelling the world economy, providing 33% of global primary energy supply, meeting over 40% of final energy demand, supplying 95% of the energy powering global transport systems, and providing feedstock for the diverse petrochemicals industry (IEA, 2012b). Since the Second World War, growth in the world economy has been strongly correlated with growth in oil consumption (Hirsch, 2008). The International Energy Agency (IEA, 2012a) has forecast that global demand for oil could grow by 14% by 2035, with all of the net additional demand projected to come from emerging economies. This rise in demand is expected to be driven almost entirely by increasing use of motorised transport for both passengers and freight as incomes rise and populations grow in developing countries.

However, there are both short-term and long-term threats to the supply of oil. The major near-term threats to supply are related to geopolitical risks and tensions. Klare (2012) has identified four "hot spot" regions that are especially vulnerable to oil-related conflict, namely the Persian Gulf in the Middle East, the East and South China Seas, the Caspian Sea area, and the Arctic. In addition, there are on-going civil conflicts in several key oil exporting nations, such as Nigeria, Iraq and Libya, which pose a significant threat to world oil supplies. The future political stability of Venezuela, the country which claims the largest proved oil reserves in the world and one of the world's top net oil exporters, is uncertain after the recent death of its former president of 14 years, Hugo Chavez. Simmering tensions between the West and Iran over the latter's nuclear enrichment programme, as well as the civil war in Syria, continue to threaten the stability of the critical Middle East region. Empirical modelling suggests that a mere 1% (900 000 barrel per day) reduction in world oil supplies could lead to an almost 20% rise in oil prices in the short term (Fournier et al., 2013: 30). Historically, major global oil price shocks, involving a doubling or more of prices, have been triggered by supply disruptions amounting to just a few million barrels per day.

For the longer term, a growing body of literature by scientists and oil industry experts is warning that the historical trend of increasing supplies of oil cannot continue indefinitely. This is because oil (like other fossil fuels), having been formed in the geological past, is a finite resource subject to depletion (Aleklett & Campbell, 2003). This finiteness necessarily implies that at some point in time, the annual production of oil at a global scale must reach an all-time maximum and begin an irreversible decline (Hubbert, 1956). This "peak oil" phenomenon, as it is commonly termed, has already been observed to occur in the majority of individual oil producing countries and in large regions such as North America and Europe (Hirsch, 2008; Sorrell et al., 2010b). Evidence suggests that the world is nearing the global oil production peak. Global new oil discoveries reached a maximum in the 1960s and have been on a declining trend ever since, despite remarkable improvements in exploration, drilling and extraction technologies, and episodes of high prices in the 1970s and 2000s (ASPO Ireland, 2009). Conventional oil production has been stagnant since 2005 (Kumhof & Muir, 2012). Based on a comprehensive review of the evidence, Sorrell et al. (2010a) warn that the global production of conventional oil might peak by 2020, and the IEA (2008) suggests that conventional oil production might have already peaked. Although unconventional oil reserves (e.g. oil sands and extra-heavy oil) are large, their flow rates are severely constrained by high energy and economic costs as well as environmental factors, and are unlikely to offset the depletion of conventional oil production for more than a few years (Robelius, 2007; Soderbergh et al., 2007; Aleklett *et al.*, 2010). The post-peak rate of decline in oil production could be between two to five percent per annum, depending on a complex combination of geological, economic and political factors (Hirsch, 2008).

For oil importing nations, and for international crude oil prices, the quantity of oil traded on international markets is of more immediate significance than total world oil production. World oil exports constituted about half of total world oil production in 2009 (EIA, 2012). Data from the United States Energy Information Administration (EIA, 2012) show that world oil exports reached a peak of 43.4 million barrels per day (mbpd) in 2005, and had declined to 40.2 mbpd by 2009 (Figure 0-1). It is highly likely that world oil exports have passed their all-time peak because domestic consumption of oil is on a rising trend in most oil-exporting countries, driven by growing populations and/or rising incomes. The rate of decline of world oil exports is likely to steepen once global oil production begins its terminal decline, and could be further accelerated if exporters withhold oil for economic or political motives (Hirsch, 2008).

Figure 0-1: World oil exports and crude oil price, 1986-2010



SOURCE: EIA (2012) and BP (2012)

Not only is the quantity of available oil set to diminish, but the energetic and economic costs of extracting the remaining oil are rising. This is principally because the easier to access oil deposits, typically discovered decades ago, are being rapidly depleted and the frontier for new oil has moved into more remote areas such as deep off-shore wells and polar regions, that are economically more costly and technically more difficult to access (Gagnon, Hall and Brinker, 2009). Thus the energy return on (energy) investment (EROI) for oil, which measures the ratio of energy delivered by the process of oil exploration and extraction relative to the energy input, is diminishing (Guilford *et al.*, 2011). The EROI for new oil and gas discoveries in US in the 1930s was about 100:1 (100 barrels of oil output for every one barrel of oil equivalent energy input), but EROI for production fell to 30:1 by the 1970s and to between 18:1 and 11:1 in 2005 (Murphy & Hall, 2010). Gagnon, Hall and Brinker (2009) found that the EROI for global oil and gas is on a declining trend, having nearly halved from 35:1 to 18:1 between 1999 and 2006. Furthermore, the EROI for unconventional oil resources such as oil sands and shale oil is estimated to be less than 5:1 (Murphy & Hall, 2010). Thus the net energy surplus (i.e., the energy output minus the energy input) yielded by oil is set to decline at a faster rate than the gross energy delivered by oil.

Thus global supplies of net oil energy will inevitably – and possibly imminently – begin an irreversible annual decline, reversing a more than century-long trend of expanding supplies of cheap oil that have underpinned world economic growth and industrialisation. The IEA (2008, 2011) has confirmed repeatedly that the world has left behind the era of cheap oil. Historically, oil price spikes and temporary supply shortages have had serious negative economic impacts on developing countries, resulting inter alia in higher rates of price inflation, deepening poverty, slower economic growth, debt crises, and civil unrest. After 2003, world oil prices trended steadily upwards from around $30 per barrel until reaching a peak of nearly $150/barrel in July 2008, contributing to the global financial crisis and ensuing Great Recession (Hamilton, 2009; Heinberg, 2011). As a result of sharply falling demand, the price of oil retreated to under $40/barrel in late 2008, but since January 2011 Brent crude has been trading persistently above $100 per barrel. These price levels are exacting a heavy toll on net oil importing economies, and also adding to social pressures in some oil exporting nations by stoking factional fighting.

Recent evidence from empirical modelling also highlights the risks of oil price shocks and their economic impacts. For example, a report published by the OECD, states that: "Based on plausible demand and supply equations, there is a risk that prices could go up to anywhere between $150 and $270 dollars per barrel in real terms by 2020, depending on the responsiveness of oil demand and supply and on the size of the temporary risk premium embedded in current prices due to fears about future supply shortages. These projections account for a negative feedback effect of higher oil prices on GDP" (Koske *et al.*, 2013: 6). This study assumed that global rates of economic growth would be slightly lower than those recorded in the period 1998-2007, and that oil supply would continue to rise, reaching about 104 mbpd by 2020. Second, an International Monetary Fund (IMF) research paper warned recently that as a consequence of rising oil demand in combination with geological constraints on supply, the price of oil could double to $200 per barrel (measured in today's dollars) by 2020 (Benes *et al.*, 2012). Another recent paper by IMF researchers modelled the potential impact of oil supply constraints on oil prices and the global economy, based on a set of scenario assumptions (Kumhof & Muir, 2012). In their relatively optimistic "baseline scenario," which assumes that oil supply growth is constrained to 1 percentage point below its 1.8% average attained between 1981-2005, and that there is a high degree of substitutability of other energy sources for oil, the real price of oil nevertheless rises 100% by 2020 (to approximately $220/barrel) and 200% after 20 years. In a "technology externality" scenario, which takes account of scientific research that demonstrates the difficulty of substituting for oil in production, the oil price rises nearly 400% after 20 years. In a "larger shock" scenario, which posits a 2% annual decline in world oil supply and a 4% per annum increase in oil extraction costs, the oil price spikes by 200% initially and climbs by a cumulative 800% after 20 years. Kumhof and Muir (2012) point out that such price increases would be "downright implausible" since economies are highly unlikely to be able to withstand such levels; demand destruction and economic recession would likely be reached at much lower oil price thresholds.

To summarise, given on-going geopolitical tensions in certain key oil producing regions, civil strife in some large oil producing nations, as well as accumulating evidence that the world is near the all-time maximum in world oil production, all nations should be preparing mitigation response plans to lessen the impact of future oil shocks. While some broad response measures, such as improving energy efficiency and conservation initiatives and investing in alternative energy sources, apply to all countries, the precise response plans that are feasible and appropriate will differ according to certain key national characteristics. Having in place a set of generic mitigation response plans could help net oil importing developing country governments to avert a great deal of economic turmoil and human suffering in the event of future oil shocks. The impact of oil shocks on oil exporting countries will clearly be very different from those of oil importing nations, and the mitigation strategies required will also differ in important respects. Nevertheless, spiking oil prices can prove to be economically and socially disruptive to such countries. There is also the risk of civil conflict amongst domestic factions or even intervention by foreign powers that vie for access to and control of hydrocarbon reserves and oil revenues.

0.2 Aims and Research Questions

The main aims of the project are to provide developing countries with a framework and methodology for identifying the major threats to socioeconomic development posed by oil price and supply shocks, and for devising national oil shock mitigation strategies in order to be able to proactively respond to such threats.

The research addresses the following questions:

- What are the key socioeconomic vulnerabilities of different categories of developing countries to oil price and supply shocks?
- What are the most appropriate oil shock mitigation strategies for different categories of developing countries?

0.3 Methodology

The methodology employed in this project consists in a systematic analysis of vulnerabilities to and likely impacts of oil shocks, and mitigation strategies to ameliorate the negative socioeconomic effects in developing countries. The analysis is based primarily on desktop research that draws on relevant academic literature, reports and policy documents concerning oil security and oil shock vulnerabilities amongst developing countries, as well as the literature on building energy security and transitioning away from oil and other fossil fuels. It also makes use of secondary data derived from various agencies including the World Bank, International Monetary Fund (IMF), International Energy Agency (IEA), United States Energy Information Administration (EIA), and BP's (2012) Statistical Review of World Energy. The analysis addresses vulnerabilities and mitigation of oil shocks in a wide range of socioeconomic areas, including the energy system, transport and mobility, agriculture and food security, the macro-economy, and social concerns such as poverty and inequality, settlement patterns and social cohesion.

Policy analysis is employed to devise generic mitigation response plans for the four country categories. It is recognised that there will be considerable overlaps among the recommendations for some of the categories, but that important distinctions can and should be made.

The project also identifies further research work that could be conducted over a longer period of time and in greater depth. This includes both the vulnerability and mitigation aspects of this work. It identifies further macro-economic implications and management of oil shocks as well as the socioeconomic impacts at a household level, in terms of poverty, inequality and household food security, and the implication of these impacts for social cohesion and political stability.

0.3.1 Generic country categories and case studies

In order to give the strategic recommendations greater traction and relevance to individual countries, the analysis is structured according to four generic categories of developing countries, namely: low income oil importing countries, lower-middle income oil importing countries, upper-middle income oil importing countries, and oil exporting countries. The rationale for this classification is as follows. Firstly, it is essential to distinguish between countries that are net importers and net exporters of oil, as the implications of international oil price shocks and/or global or local supply disruptions will generally have very different implications for these two groups of countries. Secondly, amongst the large group of net oil importing countries, it is useful to sort them according to (1) their level of reliance on crude oil and (2) their capacity to adapt to oil shocks. In practice, Gross National Income per capita serves as a useful proxy for both of these identifiers. Hence, we utilise the World Bank's (2012b) methodology for categorising countries according to their Gross National Income (GNI) per capita, measured by the World Bank Atlas method.[1] Based on 2011 data, this yields the following categories:

- low income countries (LICs): $1,025 or less
- lower middle income countries (LMICs): $1,026 - $4,035
- upper middle income countries (UMICs): $4,036 - $12,475

The study does not include any upper income countries (with GNI per capita greater than $12,475), but it does include three countries that are members of the Organisation for Economic Cooperation and Development (OECD), namely Chile, Mexico and Turkey, because these fall within the World Bank's upper middle income category.

The analysis in each of the generic country categories is extended to a greater level of depth in a representative country case study, namely Malawi, India, South Africa and Nigeria, respectively. Stakeholder consultations on the draft reports and recommendations were conducted between the researchers and key policy decision makers, experts and potential end-users in each of the case study countries. The purpose of the consultations was (1) to elicit feedback on the reports and (2) to ensure that consideration is given to the findings in policy related discussions in these countries.

1 The World Bank Atlas method uses a conversion factor, based on a moving average of exchange rates and inflation differentials relative to industrialised countries, in order to reduce the impact of exchange rate volatility on cross-country comparisons.

The sample of countries selected for the empirical analysis in Part 1 was drawn from the World Bank Development Indicators 2012 online database (World Bank, 2012). From this list, fourteen countries were excluded owing to lack of important data, namely North Korea, Myanmar, Somalia, South Sudan, West Bank & Gaza, Kosovo, and eight small island states. Three upper middle income countries, namely Argentina, Malaysia and Suriname, are border-line cases of net oil importer/exporter. According to the EIA (2012) data, they were net oil exporters in 2011, but the BP (2012) database records the former two countries as having become net oil importers in 2011 (no data are given by BP for Suriname). In any event, based on recent trends it seems highly likely that these countries will become net oil importers very soon, as their oil production is falling while domestic oil consumption is rising. Therefore these countries are counted among the net oil importing countries for the purposes of this study. A listing of all the countries included in the empirical analysis according to their generic categories is provided in Table 01 (with the number of countries in each category indicated in parentheses). The table also highlights the four representative case study countries.

The study also makes special mention of two further country categories, which cut across the income categories, namely landlocked countries and Small Island Developing States. Countries within each of these two categories share certain particular vulnerabilities to oil shocks, which are described in Part I. According to the United Nations (2007), "Small Island Developing States (SIDS) include low-lying coastal countries that share similar sustainable development challenges, including small population, limited resources, remoteness, susceptibility to natural disasters, vulnerability to external shocks, and excessive dependence on international trade. Their growth and development is often further stymied by high transportation and communication costs, disproportionately expensive public administration and infrastructure due to their small size, and little to no opportunity to create economies of scale." Lists of SIDS (as defined by the UN) and landlocked countries are provided in Table 02 and Table 03, respectively, while maps showing their location are provided in Figure 0-2 and Figure 0-3. The SIDS include three countries (Guinea-Bissau, Guyana and Suriname) which are not islands, but which share enough characteristics with the islands states to be included in this category. All of the non-high income SIDS are net oil importers with the exception of Timor-Leste.

0.4 Structure of the Report

This report is divided into two main parts. Part I deals with oil dependencies and vulnerabilities in developing countries and the likely impacts of oil price and supply shocks in a business-as-usual policy context. Each of the four major sections of Part I investigates oil shock vulnerabilities and impacts in one of the four generic developing country categories, respectively (1) low income countries, (2) lower-middle income countries, (3) upper-middle income countries and (4) oil exporting countries. Each of these major sections includes subsections on key socioeconomic characteristics, oil dependencies and vulnerabilities, and likely impacts of oil shocks. Section 5 contains a comparative summary, highlighting the similarities and differences among the four categories, and presents the main conclusions. The four country case studies (Malawi, India, South Africa and Nigeria) follow as self-contained annexes. Part II presents the oil shock mitigation strategies, again arranged in four sections corresponding to the four generic country categories. Each section considers mitigation options in the areas of energy, transport, agriculture, macroeconomic policy and social protection. This second part concludes with a comparative summary and suggests an agenda for further research.

Table 0-1: List of countries according to the generic categories

LOW INCOME COUNTRIES (31)	LOWER MIDDLE INCOME COUNTRIES (37)	UPPER MIDDLE INCOME COUNTRIES (37)	OIL EXPORTING COUNTRIES (27)
Afghanistan	Albania	Antigua and Barbuda	Algeria
Bangladesh	Armenia	Argentina	Angola
Benin	Belize	Belarus	Azerbaijan
Burkina Faso	Bhutan	Bosnia & Herzegovina	Cameroon
Burundi	Bolivia	Botswana	Chad
Cambodia	Cape Verde	Brazil	Colombia
Central African Rep.	Djibouti	Bulgaria	Congo, Dem. Rep.
Comoros	El Salvador	Chile	Congo, Rep.
Eritrea	Fiji	China	Cote d'Ivoire
Ethiopia	Georgia	Costa Rica	Ecuador
Gambia, The	Guatemala	Cuba	Egypt, Arab Rep.
Guinea	Guyana	Dominica	Gabon
Guinea-Bissau	Honduras	Dominican Republic	Ghana
Haiti	**India**	Grenada	Iran, Islamic Rep.
Kenya	Indonesia	Jamaica	Iraq
Kyrgyz Republic	Lao PDR	Jordan	Kazakhstan
Liberia	Lesotho	Latvia	Libya
Madagascar	Moldova	Lebanon	Mexico
Malawi	Mongolia	Lithuania	**Nigeria**
Mali	Morocco	Macedonia, FYR	Russian Federation
Mauritania	Nicaragua	Malaysia	Sudan
Mozambique	Pakistan	Maldives	Syria
Nepal	Papua New Guinea	Mauritius	Timor-Leste
Niger	Paraguay	Montenegro	Tunisia
Rwanda	Philippines	Namibia	Turkmenistan
Sierra Leone	Samoa	Panama	Venezuela
Tajikistan	São Tomé & Principe	Peru	Yemen, Rep.
Tanzania	Senegal	Romania	
Togo	Solomon Islands	Serbia	
Uganda	Sri Lanka	Seychelles	
Zimbabwe	Swaziland	**South Africa**	
	Tonga	St. Lucia	
	Ukraine	St. Vincent/Grenadines	
	Uzbekistan	Suriname	
	Vanuatu	Thailand	
	Vietnam	Turkey	
	Zambia	Uruguay	

NOTE: *Countries in bold text are the representative case studies.*

CREDIT: JEREMY WAKEFORD

Wood, maize and non-motorised transport: the main basis of Malawi's economy

CREDIT: LIANE GREEFF

Motor vehicle dependence in Durban, South Africa

Table 0-2: List of Small Island Developing States according to the generic categories

LOW INCOME COUNTRIES	LOWER MIDDLE INCOME COUNTRIES	UPPER MIDDLE INCOME COUNTRIES	OIL EXPORTING COUNTRIES
Comoros	Cape Verde	*American Samoa*	Timor-Leste
Guinea-Bissau	Fiji	Antigua and Barbuda	
Haiti	*Guyana*	Cuba	
	Kiribati	Dominica	
	Marshall Islands	Dominican Republic	
	Micronesia	Grenada	
	Papua New Guinea	Jamaica	
	Samoa	Maldives	
	São Tomé and Principe	Mauritius	
	Solomon Islands	*Mayotte*	
	Tonga	*Palau*	
	Vanuatu	Seychelles	
		St Kitts & Nevis	
		St. Lucia	
		St. Vincent & Grenadines	
		Suriname	
		Tuvalu	

NOTE: *Countries in italicised text were excluded from the empirical analysis owing to a lack of data.*

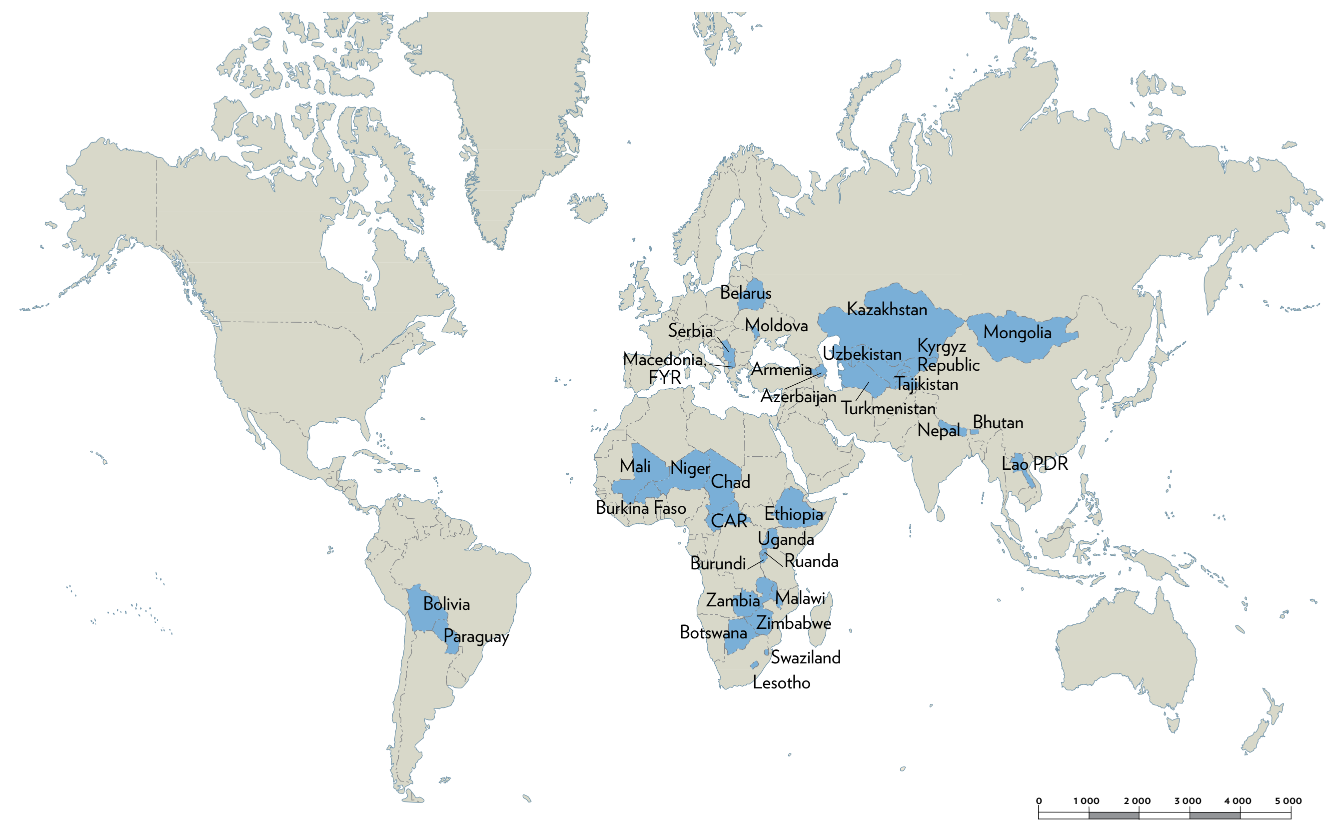
Figure 0-2: Map showing location of small island states

SOURCE: Wikipedia (2012a)

Table 0-3: List of landlocked countries according to the generic categories

LOW INCOME COUNTRIES	LOWER MIDDLE INCOME COUNTRIES	UPPER MIDDLE INCOME COUNTRIES	OIL EXPORTING COUNTRIES
Afghanistan	Armenia	Belarus	Chad
Burkina Faso	Bhutan	Botswana	Azerbaijan
Burundi	Bolivia	Macedonia, FYR	Kazakhstan
Central African Rep.	Lao PDR	Serbia	Turkmenistan
Ethiopia	Lesotho		
Kyrgyz Republic	Moldova		
Malawi	Mongolia		
Mali	Paraguay		
Nepal	Swaziland		
Niger	Uzbekistan		
Rwanda	Zambia		
Tajikistan			
Uganda			
Zimbabwe			

Figure 0-3: Map showing location of landlocked countries



part 1.

OIL SHOCK VULNERABILITIES AND IMPACTS

OIL SHOCK VULNERABILITIES AND IMPACTS

1.1 Introduction

This first part of the report concerns the vulnerabilities to and likely impacts of oil shocks on developing countries, while Part II investigates appropriate mitigation strategies and policies for countering the effects of oil shocks. In this introductory section, we provide a characterisation of oil shocks, discuss the historical occurrence of oil price shocks, define a quantitative measure of oil shock vulnerability, describe the range of generic oil shock impacts to be discussed in subsequent sections, and briefly outline Part I of the study.[2]

1.1.1 Characterisation of oil shocks

In this report we distinguish between two basic types of oil shocks: (1) oil *price* shocks (i.e. a substantial increase in the price of crude oil and consequently refined petroleum products) and (2) physical oil *supply* disruptions (i.e. a significant restriction on the available quantity of oil and derived petroleum products in a national economy).[3] In the case of net oil importing countries, oil shocks of both types emanate from the international oil market, whereas in the case of net oil exporting countries, price shocks emanate from the international market while supply disruptions are due to internal domestic factors.

In the economics literature, global oil shocks have usually been defined in terms of price fluctuations, but these may in turn be driven by changes in either the global supply of oil, demand for oil, or precautionary/speculative motives (Kilian, 2009). Historically, the supply side has been primarily responsible for observed oil price shocks, at least as an initial trigger. In practice it is unlikely for demand to grow rapidly enough to cause a sudden price shock unless it is motivated by fears of supply shortages. However, a more gradual, cumulative price shock may be driven by rapid growth in oil demand, as in the period 2005-2008 (Hamilton, 2009). 'Negative' price shocks (i.e. rapid falls in the oil price) are also possible, but are not a major concern in the part of this report dealing with net oil importing countries. Oil price plunges are of greater importance for net oil exporting countries, as discussed in Section 1.5.

There are at least three important dimensions of an oil price shock. The first is the *magnitude* of the price increase, which is usually most usefully measured in relative terms (e.g. in percentage change from a base date). When comparing various oil shock episodes over time, it is useful to use "real" oil prices, i.e. those that have been adjusted for general consumer (or producer) price inflation. The second aspect of an oil price shock is the *speed* or suddenness with which the price rises, e.g. over a period of one or two quarters or more than a year. The speed of a shock is important as it affects the

2 Much of this introductory material is adapted from Wakeford (2012).

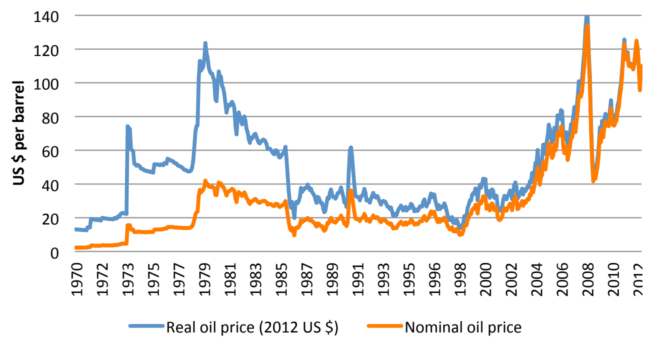
3 Gupta (2008) refers to oil price shocks in terms of "market risk", and to supply shocks in terms of "supply risk".

ability of economies to adjust, which is typically very restricted in the short run (up to one year). The third dimension is the *duration* of the price increase, i.e. whether it is temporary or more permanent, since this carries implications for the extent and durability of the consequences. Physical oil supply shortages at the global level have historically been rare and isolated events, but will likely become more pervasive after global oil production begins its inevitable long-term decline (see the discussion in the Introduction). Our emphasis in this report is on the various energy uses of oil, since the non-*energy* uses of oil (e.g. as feedstock for petrochemical products and lubricants) constitute a relatively minor share (approximately 16%) of global oil consumption (IEA, 2012a) and because it is generally more difficult to find substitutes for these applications. The following subsection reviews the historical record of oil price shocks.

1.1.2 Historical occurrence of international oil price shocks

The conventional view is that there have been four international oil price shocks in the post-World War II era: 1973-4; 1979-80; 1990; and 2007-2008 (Hamilton, 2009; and see Figure 1-1). These shocks each involved at least a doubling of the oil price within a year or two.[4] In real dollar terms, the oil price in 2008 briefly exceeded the maximum level reached in 1980, which was the previous highest level; the 1974 and 1990 local maxima were substantially lower.[5] In percentage change terms, however, the 1973/4 shock clearly stands out, as oil prices rose by 250% in one year. In 1979/80, the price rose by approximately 130%. In 1990 the oil price rose by approximately 100% but fell abruptly within a year. In contrast, the 2007/8 shock was more cumulative in nature: the annual percentage increase in dollar oil prices did not exceed 40% between 2004 and 2008, but cumulatively the price rose 230% over 5 years. The following paragraphs briefly explain the causes and consequences of each oil shock.

Figure 1-1: Nominal and real monthly Brent crude oil prices, 1970-2012



SOURCE: IMF (2012) and own calculations

NOTE: *The real oil price is obtained by deflating the nominal dollar price by the US consumer price index with base year 2012.*

The first oil shock was catalysed by the Arab-Israeli war, which resulted in various Arab oil-producing nations placing an embargo on oil exports to the Unites States and several other countries that were seen as strongly pro-Israel. In addition, the Organisation of Petroleum Exporting Countries (OPEC) asserted its oligopolistic power in the oil market by colluding to reduce production volumes by 5% and thereby collectively setting the price (van der Merwe & Meijer, 1990: 6). The oil price rose by a factor of nearly four, from about $3 per barrel prior to the war to $11.50 per barrel in 1974, and stayed at this level until the next shock in 1979. This first oil shock had severe repercussions for many of the advanced industrial economies, including sharply rising producer and consumer prices – which induced a wage-price spiral – and a recession; hence the term 'stagflation' entered the lexicon. Subsequently, developing countries suffered from the decline in world trade and a fall in primary commodity prices (Dagut, 1978: 29).

The second oil shock occurred in the wake of the Iranian Revolution in 1978-79 and the subsequent outbreak of war between Iraq and Iran in 1980, which caused Iranian (and later Iraqi) oil exports to dry up altogether. Again, approximately 5% of world oil production was taken off the markets. As in the previous oil crisis, the magnitude of the price hike (almost a three-fold increase) was exacerbated by panic reactions and hoarding behaviour (van der Merwe & Meijer, 1990: 6). This oil shock gave rise to another serious bout of inflation internationally, especially in the heavily oil-dependent industrial nations. Rather than accommodating the inflation as in 1974, many central banks – notably the US Federal Reserve Bank – raised interest rates significantly to quell inflationary expectations. This action contributed to a severe international recession and a debt crisis among many developing countries that borrowed money in order to continue importing oil.

The third oil price shock was triggered by the Iraqi invasion of Kuwait in August 1990. As a consequence of fear-driven stockpiling and the elimination of Iraq and Kuwait's approximately seven percent share of daily world oil production following the imposition of United Nations sanctions, the price of oil climbed by a factor of about two from $17 per barrel in July 1990 to an average of $35 per barrel in October. However, the shock proved to be short-lived, with the price dropping to below $20 per barrel by February 1991. The quick retreat in the oil price was thanks mainly to the rapid deployment of US and Allied military forces and their swift victory in the Gulf War in early 1991, which prevented the crisis from spreading and calmed sentiments in the oil markets. Again, this episode demonstrated the importance of expectations in determining the level of oil prices. Some major industrialised nations (e.g. the US, UK and Germany) suffered a fairly severe recession around this time, which was exacerbated by – but not entirely due to – the oil spike. The impact on developing countries was generally less severe.

After averaging roughly $20 per barrel between 1986 and 2003, the price of crude oil rose steadily for several years, reaching $64/barrel on average in 2006. It then spiked more dramatically, reaching a record high of US$147 per barrel in July 2008 (see Figure 1-1). Subsequently, the oil price fell sharply to about $40 per barrel by December 2008. There was intense debate in the media over the causes of the fourth oil shock. Most probably it was a combination of several factors. Fundamentally, the balance between supply and demand in the oil market gradually tightened between 2005 and 2008 (Hamilton, 2009). This is partly attributable to steeply rising demand on the back of robust global economic growth, especially in large emerging economies such as China and India. At the same time, crude oil supply essentially flattened out and world oil exports ceased growing and then began to decline (see the Introduction). This stagnation in supply can be attributed to a range of factors, including: a lack of sufficient investment in oil production; disruptions to oil production in conflict-ridden areas such as Iraq and Nigeria; and the decline in production from mature oil fields. In addition, speculative activity by institutional investors taking advantage of tight conditions in the oil market most probably amplified the price rise, especially in 2008. A third contributing factor was a decline in the value of the dollar during much of this period, which pushed up the dollar-denominated price of oil and other commodities. Overall, Hamilton (2009) argues that the tight supply/demand balance was the major factor. Rising interest rates together with growing household expenditures on energy and food were major factors responsible for the bursting of the US housing bubble from mid-2006, which in turn triggered the financial crisis of 2008 (Hamilton, 2009) and the so-called 'Great Recession' – the first global recession since the Second World War.

In summary, each of the four historically identified oil price shocks involved at least a doubling of the nominal oil price within a few months or at most two years. The three earlier shocks were triggered mainly by sudden supply disruptions caused by geopolitical events, while the more recent shock was driven by a combination of rapidly rising demand and stagnating supply, and exacerbated by a speculative commodity bubble.

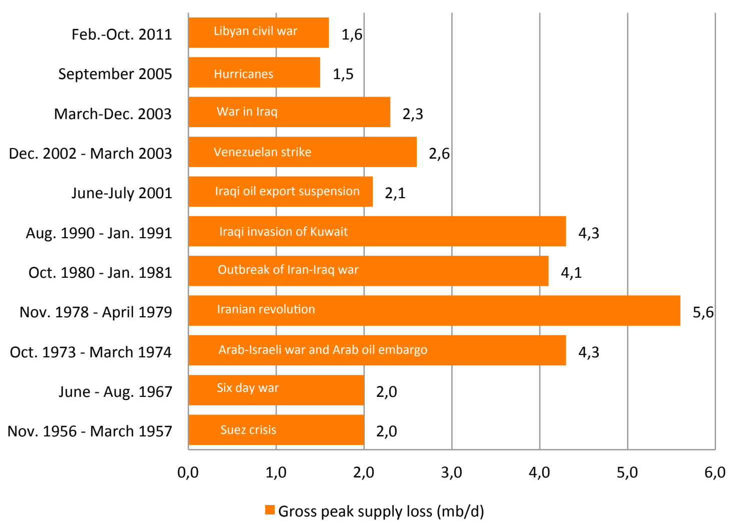
4 The dollar price of oil rose by 140% between December 1998 and December 1999, which could be construed as an oil shock. However, at least part of this rise was a correction back towards the longer run trend following the aftermath of the Asian Financial Crisis of 1997, which depressed the oil price below the long-term average. The 1999 price rise is not usually regarded as an oil shock (see Hamilton, 2009). In addition, the oil price trebled between 2003 and 2006, but this was a more gradual upward trend and therefore is not interpreted as a (sudden) shock. A 'reverse' or negative oil shock occurred in 1986 after the Organisation of Petroleum Exporting Countries (OPEC) flooded the international market with oil.

5 After plunging from a high of $147 per barrel in July 2008 to $40 per barrel in December that year, the oil price once again rose sharply to a sustained level over $100 for most of 2011 and the first half of 2012. Most if not all of this price increase could be viewed as a correction of the foregoing price plunge, which resulted from the financial crisis and ensuing 'Great Recession'; thus it is not treated as a separate oil shock here.

1.1.3 Historical occurrence of international oil supply shocks

Historically, the main triggers of significant oil supply shocks have been geopolitical or civil conflicts involving major oil exporters (see Figure 1-2). Other typical reasons for disruptions to global oil supplies include capacity constraints or technical supply problems, natural disasters such as extreme weather events (e.g. seasonal storms in the Gulf of Mexico), terrorist attacks on energy infrastructure, and inter-governmental disputes (IEA, 2013a). Of the eleven major oil supply shocks that have occurred in the post-World War II era, six have resulted from international conflicts and two from civil conflicts – all of which have occurred in the Middle East and North Africa (MENA) region. Since its formation in 1974, the IEA has authorised a release of oil from its member countries' strategic stocks on just three occasions: after the Iranian revolution in 1978; in response to the impact of Hurricanes Katrina and Rita on oil production facilities in the Gulf of Mexico in 2005; and to offset the loss of Libyan production during its civil war in 2011.

Figure 1-2: Major oil supply shocks



SOURCE: Adapted from IEA (2007)

1.1.4 Oil shock vulnerability

In the context of internationally determined oil prices, the vulnerability of an oil-importing country to *oil price shocks* can be measured in terms of the ratio of spending on imports of crude oil and oil products to gross domestic product (GDP) (Bacon & Kojima, 2008). This ratio can be decomposed into six sub-components, as displayed in the equation below: the price of oil in US dollars; oil import dependence (the proportion of domestic oil consumption that is imported); oil resource dependence (the ratio of oil use to total energy use); the energy intensity of the economy (the ratio of energy use to real gross domestic product, measured in local currency units); an inverse of the price deflator (the ratio of real GDP to nominal GDP); and a measure of the nominal exchange rate (nominal GDP in current local currency units divided by nominal GDP in current US dollars). Accordingly, changes over time in oil vulnerability will be determined by changes in crude oil prices, oil import dependency, oil intensity, energy intensity, and the real exchange rate (Bacon & Kojima, 2008). Developing countries tend to have higher energy intensity than developed economies, since the share of primary and secondary sectors such as agriculture, mining and manufacturing tends to be larger relative to less energy intensive service sectors. Developing countries are also typically more prone to exchange rate fluctuations. Oil intensity is usually determined by local factors such as the presence or absence of alternative energy supplies (e.g. gas or coal).

$$\frac{\textit{oil imports (\$)}}{\textit{GDP(\$)}} = \textit{oil price (\$)} \times \frac{\textit{oil imports}}{\textit{oil use}} \times \frac{\textit{oil use}}{\textit{energy use}} \times \frac{\textit{energy use}}{\textit{real GDP}} \times \frac{\textit{real GDP}}{\textit{GDP}} \times \frac{\textit{GDP}}{\textit{GDP(\$)}}$$

where:

- oil imports ($) is the value in US dollars of oil imports per year
- oil imports is measured in quadrillion Btu per year
- oil use is measured in quadrillion Btu per year
- energy use is total primary energy supply measured in quadrillion Btu per year
- real GDP is the value of GDP in constant local currency
- GDP is the value of GDP in current local currency
- GDP($) is the value of GDP in current US dollars

In addition to the foregoing factors, the extent of foreign exchange reserves and GDP per capita are both indicators of a country's ability to pay for more expensive oil, at least in the short term, and are therefore inversely related to oil vulnerability (Gupta, 2008: 1197).

An oil-importing country's vulnerability to *physical oil supply shocks* is determined by a range of factors, including:

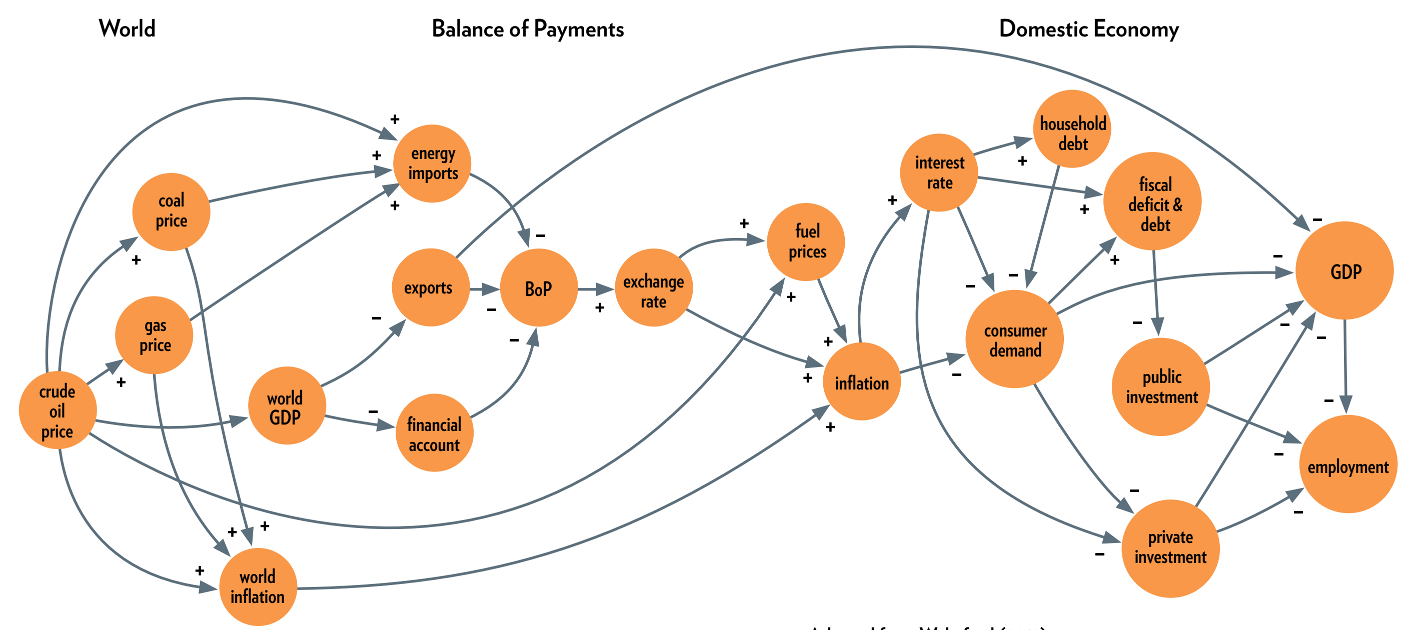
- the size of strategic petroleum reserves (relevant to short-run vulnerability);
- the ratio of domestic oil reserves to oil consumption (relevant to long-run vulnerability);
- the ratio of domestic oil production to oil consumption;
- diversification of supply sources; and
- exposure to geopolitical risks associated with oil suppliers.[6]

1.1.5 Macroeconomic transmission of oil price shocks for oil importers[7]

International oil price shocks are transmitted to a national economy through two main channels: indirectly via their impact on the global economy, and directly through higher prices of imported crude oil and refined fuels. These channels are summarised in Figure 1-3 below and are discussed in greater detail in the paragraphs that follow.

The indirect impact of an oil price shock on a national economy is transmitted via the balance of payments, which includes the current account (exports less imports, plus net factor payments from abroad) and the financial account (net portfolio plus foreign direct investment inflows/outflows). In the first instance, a rise in the crude oil price tends to increase a country's oil import bill. This is because price elasticities of demand for oil tend to be very low in developing countries in the short-run (i.e., within one year), on the order of 0.05 (meaning that a 100% rise in the price of oil leads to only a 5% decline in oil demand) (Bacon, 2005). Even in the long run, price elasticities may be as low as 0.20, which indicates the extent of dependence on oil. Secondly, a rise in the oil price tends to result in increases in the prices of energy substitutes such as coal and gas. Thus for the majority of developing countries, which are net importers of coal and gas as well as oil, the energy import bill will rise, assuming an inelastic demand for energy. Thirdly, an international oil price shock means that foreign consumers have to spend a greater proportion of their incomes on oil (and gas and coal), and hence have less money to spend on other imported goods and services, and hence exports for the domestic economy decline. If foreign monetary authorities raise

Figure 1-3: Macroeconomic transmission of an oil price shock



SOURCE: Adapted from Wakeford (2012)

NOTES: *A + (-) sign next to an arrow indicates that an increase in the base variable is assumed to lead to an increase (decrease) in the target variable, ceteris paribus. BoP = balance of payments.*

6 See Gupta (2008: 1197).

7 Transmission of oil shocks to net oil exporting countries is dealt with in Section 1.5.

interest rates in order to curb inflationary pressures, the likely result is decreased consumption and investment expenditure and hence a decline in economic growth in foreign countries. Thus an oil shock typically results in diminished demand for many tradable goods and services, i.e. a contraction in world demand for exports. However, demand for certain specific export commodities might actually rise in response to an oil price shock, at least in the medium term. Examples include substitute energy sources such as coal, gas and uranium, as well as renewable energy technologies and more energy-efficient machines and appliances. The demand for gold is also likely to rise as gold is seen as a hedge against inflation and a store of value during periods of economic and financial risk and uncertainty. The aggregate net change in demand for any particular country's exports will depend on the composition of their export offerings and changes in the relative terms of trade. Most countries, however, will likely suffer from a contraction in export demand.

A further impact on the balance of payments results from the uncertainty created by oil price shocks. This typically raises perceptions of risk, particularly with respect to emerging market economies, and usually results in capital flight toward industrialised countries that are considered relatively safe. For most countries, especially smaller ones, the combination of capital flight, a higher oil import bill and reduced demand for (most) exports is likely to weaken their local currencies. In addition, an oil price shock tends to fuel inflation in the majority of oil importing countries and thus raise the world inflation rate, which in turn implies price inflation for imported goods and services for individual developing countries.

The immediate direct effect of an oil price shock is to raise the prices of liquid transport fuels (petrol, diesel, jet fuel and heavy fuel oil), paraffin, LPG and other oil-based petrochemical products in the home country. The fuel price shock will be exacerbated to the extent that the country's exchange rate weakens (depreciates). Higher fuel prices boost the general rate of producer and consumer price inflation directly, and also indirectly by raising the costs of transported commodities, especially food products. In addition, there is a likelihood of second round effects on inflation expectations and associated wage-price spirals, which have the potential to extend the inflationary impact beyond the initial once-off rise following an oil price hike.

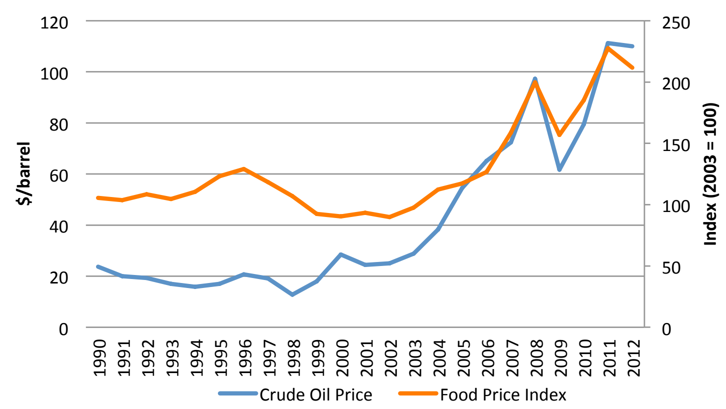
If the monetary authorities raise interest rates in an attempt to contain inflation, household and private debt service costs will rise, and the appetite for new debt will decline, thereby dampening consumer spending and private investment. Furthermore, oil shocks can be expected to generate increased volatility in and uncertainty about inflation, interest rates, exports, and the exchange rate, and therefore could undermine confidence, consumption and investment. Together, these macroeconomic effects will undermine GDP growth. National income (measured by GDP) will also suffer a negative income effect as the oil import bill rises; the magnitude of this impact will depend on the proportion of household consumption expenditure devoted to petroleum products (Hamilton, 2009). GDP will contract further to the extent that world demand for the local country's exports is depressed. Weaker private and public investment and slowing GDP growth will tend to reduce demand for labour and raise the unemployment rate. In some industries the higher cost of fuel could encourage a degree of substitution of labour for machine capital, especially where the latter relies directly on petroleum fuels, but this is unlikely in the short run.

A transitory oil price spike would not generally be expected to have major long-term consequences, especially for economically stronger developing countries. However, a sustained oil price shock would set in motion a series of behavioural adjustments on both the supply side and the demand side in the medium to longer term. On the supply side, one can anticipate a possible substitution of alternative energy sources, although this might be constrained if the prices of alternatives also rise. In the long run, one can expect structural changes in the economy away from oil-intensive sectors and towards higher labour intensity of production. On the demand side, the behavioural responses of households and businesses will depend on the magnitude of relative price changes as well as the extent to which they regard an oil price shock as temporary or permanent (Fofana, Mabugu & Chitiga, 2008: 12). A lasting oil price shock will induce greater energy efficiency and conservation by both producers and consumers. However, in the short to medium term demand for oil tends to be highly inelastic as most oil-burning capital equipment and appliances cannot be substituted for immediately (Nkomo, 2006: 14). In the longer term, there is likely to be a shift towards less oil-intensive capital equipment, such as electric trains and vehicles and even a new approach to spatial development. Positive responses such as these are dealt with in Part II of this report.

1.1.6 Other oil shock impacts

In addition to evaluating the general macroeconomic impacts of oil shocks, the sections that follow will also identify the most vulnerable economic sectors in each of the country categories. In general, these are expected to include those sectors which rely most heavily on petroleum-based transport, such as agriculture, mining, construction, and tourism. The impacts on transport and mobility will depend on the relative importance of various modes of both passenger and freight transport, e.g. road versus rail, and motorised versus non-motorised transport. The detailed sections will also identify socioeconomic impacts of oil shocks, such as poverty and inequality, food security (which will depend *inter alia* on the balance between subsistence/traditional farming and industrialised agriculture), settlement patterns (influenced by the urbanisation rate and population density), and social cohesion (depending for instance on the extent of ethnic diversity and political tension). One of the key indirect impacts of oil price shocks is their role in boosting international food prices, as shown in the following figure.

Figure 1-4: Crude oil price and world food price index, 1990-2012

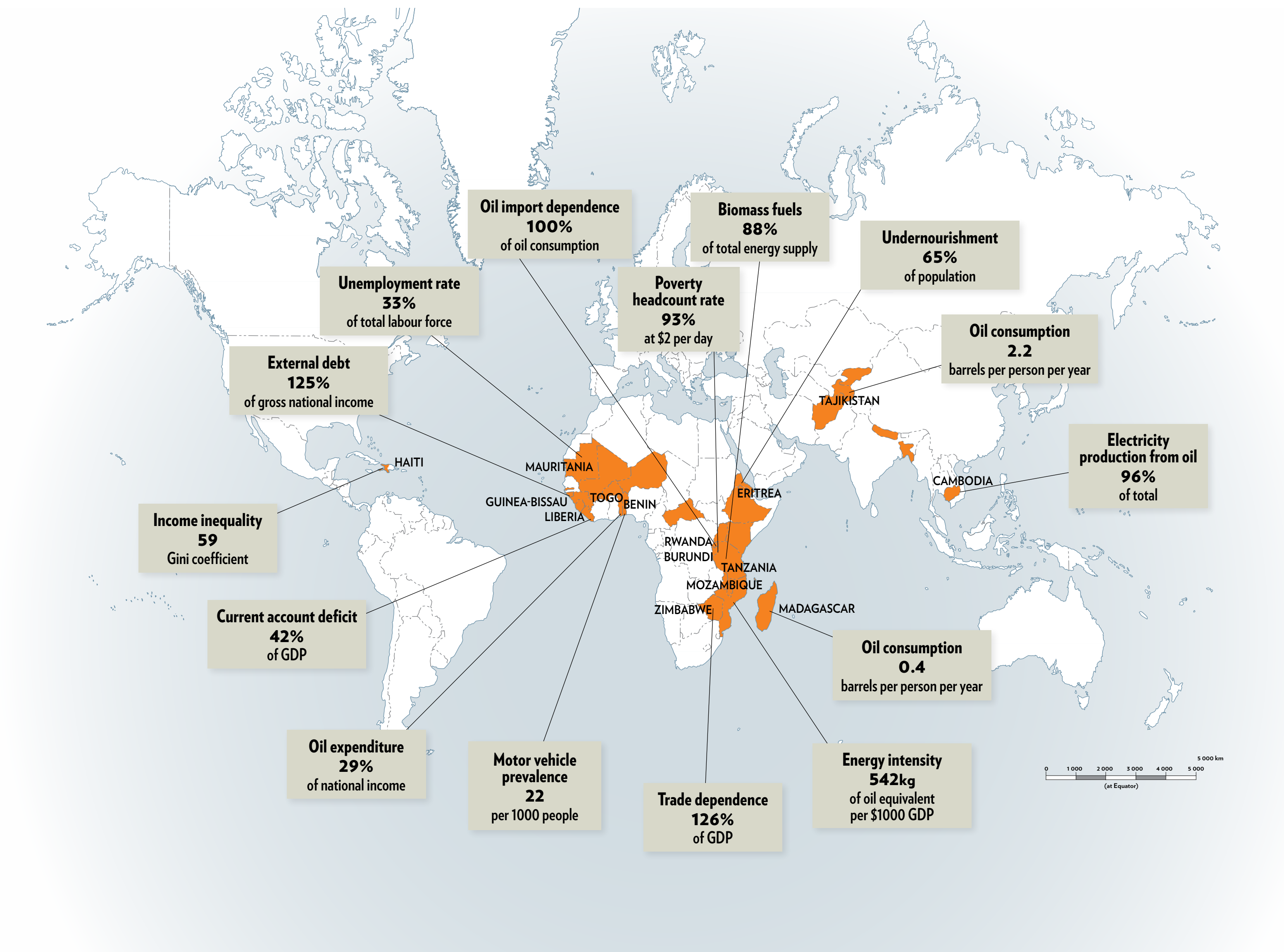


SOURCE: FAO (2012)

1.1.7 Outline of Part 1

The remainder of the Part 1: *Vulnerabilities and Impacts* is organised as follows. Each of the four major sections 1.2 through 1.5 deals with oil shock vulnerabilities and impacts in one of the four generic developing country categories, namely: (1) low income countries, (2) lower middle income countries, (3) upper middle income countries and (4) oil exporting countries. Each of these major sections includes subsections on key socioeconomic characteristics, oil dependencies and vulnerabilities, and likely impacts of oil shocks. Section 1.6 contains a comparative summary, highlighting the key similarities and differences among the four categories, and presents the main conclusions. The four country case studies (Malawi, India, South Africa and Nigeria) are presented as self-contained reports organised according to a consistent analytical framework.

1.2 Low Income Countries



This section analyses the major oil dependencies and likely vulnerabilities to and impacts of oil price and supply shocks on low income countries (LICs). Low income countries are defined by the World Bank as those with gross national income (GNI) per capita of less than $1,025 in 2011. The analysis is based largely on data drawn from the World Bank (2012) Development Indicators and U.S. Energy Information Administration (EIA, 2012). Our sample includes 31 such countries that were net oil importers in 2011 and for which there were a minimum of meaningful data available. Data were not available for all variables for all of the selected countries. The following subsections respectively present the key socioeconomic characteristics of these countries, analyse various indicators of oil vulnerability, and discuss the probable impacts of oil price and supply shocks.

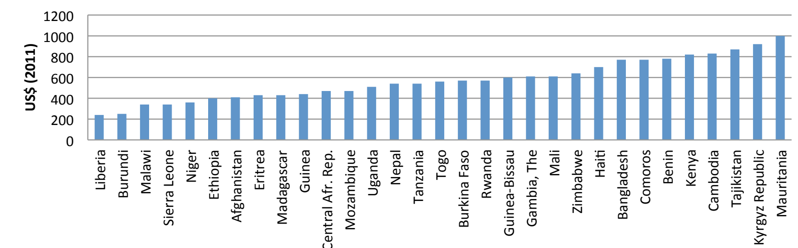
1.2.1 Key socioeconomic characteristics

This section presents key data on economic, socioeconomic and demographic characteristics of low income countries. All of these indicators are related in some way to countries' vulnerabilities and/or capacities to adapt to oil price and supply shocks.

Economic indicators

Figure 1-5 displays the gross national income (GNI) per capita for the 31 LICs in our sample. The poorest amongst the countries in terms of income per head include Liberia ($240), Burundi ($250) and Malawi ($340), while the least poor is Mauritania ($1000) (Figure 1-5). The average GNI per capita for this sample is $574, while the median is $560. The absolute size of most of these economies (measured in terms of GNI) is also very small, with the exception of Bangladesh, which has a very large population of 150 million. The low levels of income that characterise the LICs imply that their ability to adapt to rising oil prices, for example by investing in alternative energy infrastructure, is highly constrained.

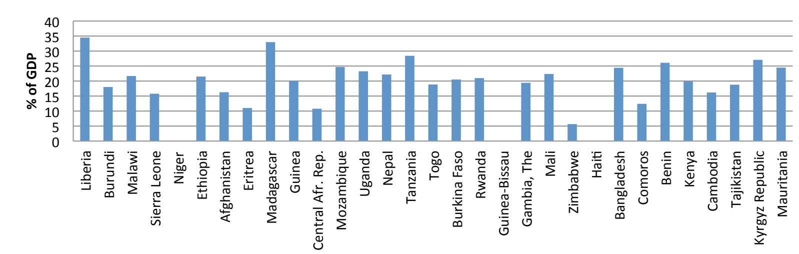
Figure 1-5: Gross national income per capita in LICs, 2011



SOURCE: World Bank (2012)

A second useful economic indicator is gross fixed capital formation (GFCF) expressed as a percentage of gross domestic product (GDP). This ratio indicates investment in physical capital and therefore how solid a foundation is being laid for future economic growth. GFCF averages 21% of GDP (with a median of 21%) in the sample. GFCF varies widely from a high of 35% in Liberia to a dismally low figure of 6% in Zimbabwe (Figure 1-6). The potential of GFCF to alleviate the impact of oil shocks depends on what kinds of investments are being made, e.g. whether they involve oil-dependent infrastructure such as roads, or alternative energy generation (e.g. hydroelectric power plants).

Figure 1-6: Gross fixed capital formation in LICs, 2010

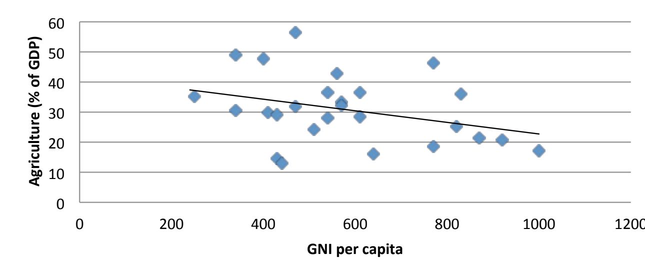


SOURCE: World Bank (2012)

NOTE: *No data were available for some countries (Niger, Guinea-Bissau and Haiti in this instance). In future figures, missing values indicate lack of data rather than zero values, unless otherwise stated.*

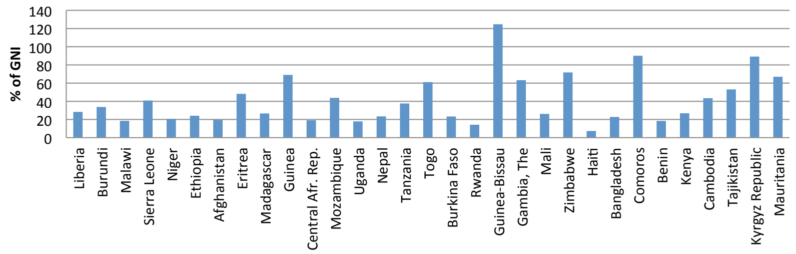
One of the key distinguishing features of LICs is that the share of agriculture in the economy (GDP) is relatively large – 31% on average in our sample – while the contributions of industry (averaging 22%) and services (47%) are smaller than in wealthier countries. This composition reflects the fact that these countries are still in the very early stages of the transition from agrarian to industrial socioeconomic regimes. Within the LIC sample, there is a weak negative correlation (-0.33) between the share of agriculture and GNI per capita, which is further illustrated in Figure 1-7.

Figure 1-7: Gross national income per capita and agriculture's share of GDP in LICs



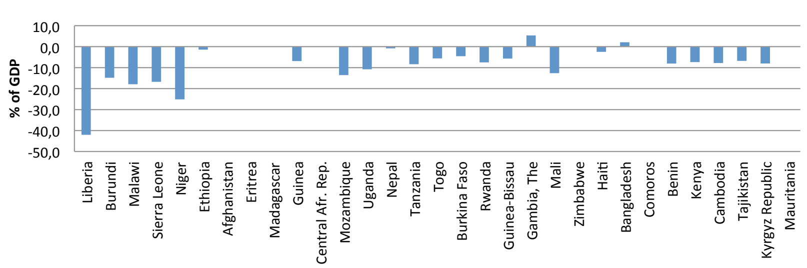
SOURCE: World Bank (2012)

Figure 1-8: External debt stocks in LICs, 2010



SOURCE: World Bank (2012)

Figure 1-9: Current account balance in LICs, 2010



SOURCE: World Bank (2012)

Several economic indicators specifically related to the balance of payments are relevant to understanding countries' vulnerability to the macroeconomic impacts of oil price shocks. A large external debt constrains a country's ability to absorb exogenous economic shocks and renders it vulnerable to currency depreciation and in extreme cases, a debt crisis. The average external debt stock measured as a percentage of GNI is 41% in the LIC sample, while the median is significantly lower at 28%. The countries most at risk in this group are Guinea-Bissau (125%), Comoros (90%) and Kyrgyz Republic (89%), although a number of countries have debt ratios comfortably below 30% and thus have moderate debt risk (Figure 1-8). There is a moderate correlation between the size of the external debt and the level of interest payments on the debt (correlation coefficient of 0.6). The Kyrgyz Republic pays the highest percentage of GNI on interest payments (1.64%), while for the majority of the countries the ratio is well below 1% and the median is just 0.21%. This is partly because of the low prevailing world interest rates, as well as preferential lending terms for low income countries. Total reserves as a percentage of external debt indicates a country's ability to cope with sudden shocks to its balance of payments, such as a higher oil import bill or a fall in export earnings. The median is 51%, while the average is somewhat higher at 63% due to the presence of a few outliers such as Afghanistan (225%), Haiti (272%) and Rwanda (102%). Eritrea, Guinea-Bissau, Mauritania and Tajikistan each has reserves at less than 20% of external debt and is thus highly exposed to balance of payments shocks.

The current account balance (Figure 1-9) is another important indicator of macroeconomic vulnerability, since a large deficit implies a constrained ability to afford more expensive oil imports and a risk of rapid currency depreciation. Only two countries in this sample, namely Bangladesh and The Gambia, had current account surpluses in 2010. The most extreme deficits were recorded by Liberia (-42% of GDP) and Niger (-25%), but any deficit greater than 5% of GDP represents a considerable risk.

Finally, the more a country depends on trade, the greater is its exposure to the impact of higher transport costs (resulting from oil price shocks) as well as the negative impact of oil shocks on world export demand. In five LICs (Kyrgyz Republic, Mauritania, Liberia, Cambodia and Zimbabwe), the sum of exports and imports was greater than GDP in 2010, indicating a very high dependence on international trade and a large exposure to trade-related risks (Figure 1-10). The average ratio of trade to GDP among the LICs is relatively high at 71%, reflecting the fact that many of these countries are dependent on commodity exports and manufactured imports.

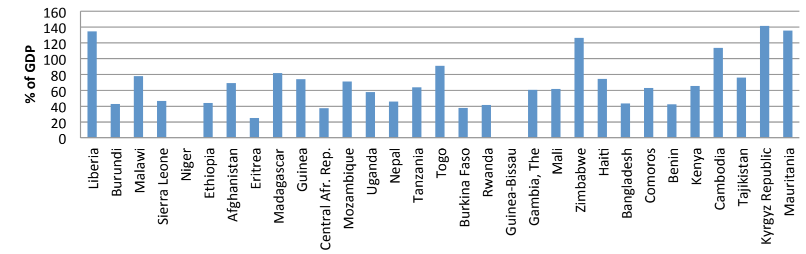
Socioeconomic indicators

Socioeconomic characteristics give an important indication of how well or badly countries' people will be affected by oil shocks. In general, one may expect that the greater the degree of income inequality, the greater the chance of domestic social stress, and associated crime and violence, following an economic shock. The average Gini coefficient[8] for the LIC sample is 40, while the median is 39. The highest Gini figures in the sample are Haiti (59) and Central African Republic (56), while the lowest are Afghanistan (28) and Ethiopia (30) (Figure 1-11). The depth of poverty indicates how vulnerable a country's citizens are to increases in the basic costs of living, such as fuel and food prices, which are strongly affected by world oil prices. Poverty rates are extremely high in most LICs, with a country average of 71% of the population counted as poor at the $2 per day measure (Figure 1-10), and almost half (48%) at the $1.25 per day measure of extreme poverty. Thirteen of the LICs for which there are data have $2/day poverty rates over 70%.

Undernourishment (Figure 1-12) is also a very large problem in LICs, affecting on average 29% of the population and over half in three countries (Haiti, Eritrea and Burundi). This means that further spikes in food prices could have devastating effects on these populations. Interestingly, extreme poverty is only moderately correlated (coefficient = 0.51) with undernourishment in this sample, which shows that average incomes are just one factor explaining access to adequate nutrition. The unemployment rate in most LICs is comparatively low (averaging 7%), with the notable exceptions of Mauritania (31%) and Ethiopia (21%). This partly reflects the fact that subsistence agriculture provides

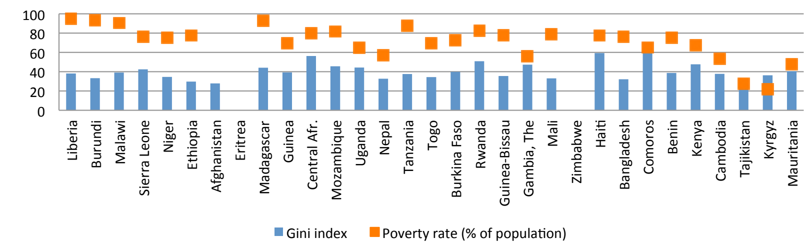
8 A Gini index value of 0 represents perfect equality, while an index value of 100 implies perfect inequality.

Figure 1-10: Trade as a percentage of GDP in LICs, 2010



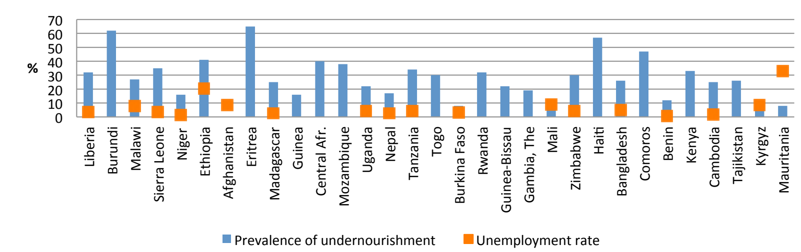
SOURCE: World Bank (2012)

Figure 1-11: Gini index and headcount poverty rate ($2/day) in LICs



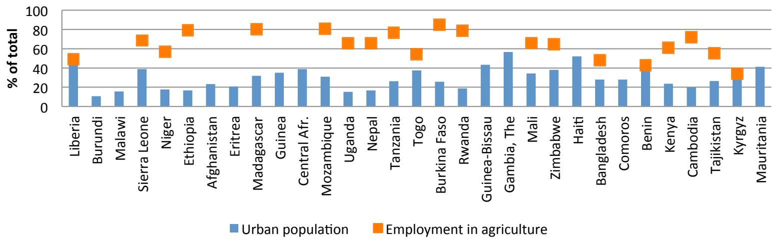
SOURCE: World Bank (2012)

Figure 1-12: Prevalence of undernourishment and unemployment in LICs



SOURCE: World Bank (2012)

Figure 1-13: Urban population and percentage of workers in agriculture, LICs



SOURCE: World Bank (2012)

back-stop employment for most working age people in these relatively undeveloped economies.

Certain demographic characteristics of countries have a bearing on their vulnerability or resilience to oil shocks. Population density (people per square kilometre) can be important in times of food crisis, as social pressures and conflict are in general likely to be more intense in high-density countries. On the other hand, higher settlement densities may imply a lower vulnerability to increases in transport costs. Amongst the LICs, the average and median population densities are 143 and 60 persons per square kilometre, respectively; the higher average is skewed by the very high densities in Bangladesh (1,142), Rwanda (483), Haiti (363) and Burundi (326). It is notable that the latter three of these countries have experienced intense social conflict in the recent past. Another important indicator of a country's state or stage of development is the percentage of population residing in urban areas. For LICs in 2010, the average urban population proportion was 30% and the median was 28%. The highest urbanisation rates were recorded in The Gambia (57%), Haiti (52%) and Liberia (48%), while the most rural populations were in Burundi (11%), Uganda (15%), Malawi (16%), Nepal (17%) and Ethiopia (17%) (Figure 1-13). In the LICs, per capita oil use is only weakly correlated (correlation coefficient 0.32) with the urbanisation rate. Finally, the proportion of workers employed in agriculture tends to be high in many LICs: over 80% in three countries (viz. Burkina Faso, Madagascar and Mozambique) and 64% on average (Figure 1-13). These proportions dwarf the average of 9% employed in industry and 26% in services. One advantage of this vis-à-vis oil shocks is that a smaller proportion of workers rely on oil-based transport to access their place of work and sources of food. Another is that oil shocks will in general have a larger impact on industry than on largely non-mechanised subsistence agriculture.

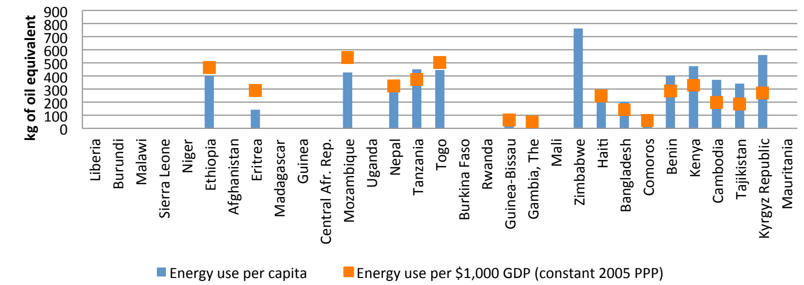
1.2.2 Oil dependencies and vulnerabilities

While the socioeconomic and demographic characteristics of LICs provides the broad context for how they will be affected by oil shocks, the more immediate vulnerabilities are determined by the extent to which countries depend on oil to meet their energy needs. This section examines data on energy, oil production and consumption, measures of oil vulnerability, and transport sector oil dependence.

Energy indicators

An important measure of a country's energy intensity is energy consumption per capita, measured here in kilograms of oil equivalent, which in three of the LICs (Comoros, The Gambia and Guinea-Bissau) is extremely low at below 100 kg/person (Figure 1-14). At the high end of the scale are the Kyrgyz Republic (559) and Zimbabwe (763), while the average (median) energy consumption is 341 (371) kg/person. A second measure of energy intensity is energy use (kg of oil equivalent) per $1000 of GDP (measured in constant 2005 dollars at purchasing power parity). This is also extremely low in the three countries mentioned above, but highest in Mozambique (542) and Togo (503). The per capita and per GDP energy intensity measures are fairly strongly correlated in this sample (with a coefficient of 0.73). Both measures of energy intensity are on the whole much lower than for the higher income category countries, since energy consumption is associated strongly with industrialisation (on the production side of the economy) and with rising incomes (on the demand side).

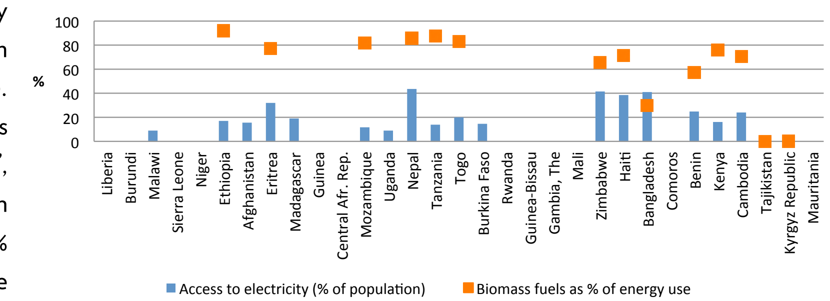
Figure 1-14: Energy intensity in LICs



SOURCE: World Bank (2012)

The percentage of the population with access to electricity, which is an important indicator of the quality of energy services available, is extremely low (less than one-fifth) in several of the LICs and just 23% on average (Figure 1-15). On the other hand, the contribution of biomass fuels (also called "combustible renewables and waste energy", i.e. mostly traditional fuels for cooking and heating such as wood and animal dung) to total energy is over 70% in the majority of the LICs for which data are available (Figure 1-15). The average (66%) would be higher were it not for the fact that two former Soviet Republics (Kyrgyz Republic and Tajikistan) reportedly use no traditional biomass fuels. As would be expected, there is a moderate negative correlation (-0.49) between access to electricity and proportion of energy derived from traditional biomass fuels, since electricity is a modern form of energy which often replaces wood and animal dung for cooking when it is available.

Figure 1-15: Access to electricity and use of biomass fuels in LICs

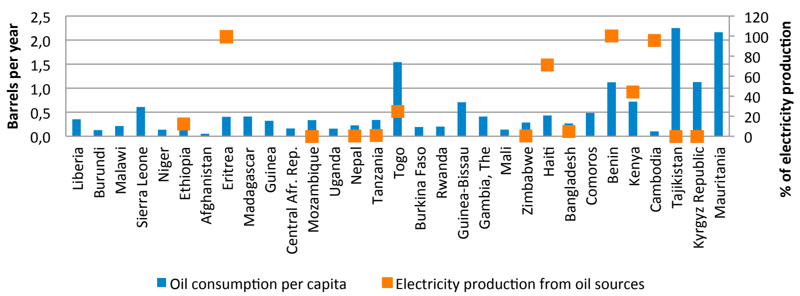


SOURCE: World Bank (2012)

Oil consumption and production

It is notable that only four of the 31 LICs produced any oil in 2011, and they were all very meagre amounts of less than 10 000 barrels per day (bpd). The largest oil consuming countries (Bangladesh, Kenya, Ethiopia and Tanzania) were also amongst the most populous LICs. Just seven of the LICs have any domestic crude oil refining capacity. The remaining 24 countries are particularly at risk in times of fuel supply disruptions or shortages, as they are at the very end of the fuel supply chain. Oil consumption per capita is extremely low (less than half a barrel per person per year) in 22 of the 31 countries and very low on average at 0.5 barrels per person per year (Figure 1-16). The relative outliers amongst the LICs, which are therefore more vulnerable to oil shocks, are Benin, Kyrgyz Republic, Mauritania, Tajikistan and Togo (where per capita consumption is greater than one barrel per year).

Figure 1-16: Oil consumption per capita and electricity production from oil in LICs



SOURCE: World Bank (2012)

The percentage of electricity produced from oil sources is another extremely important indicator of a country's vulnerability to oil price and especially supply shocks. Three countries in the sample (viz. Benin, Cambodia and Eritrea) are almost completely dependent on oil for power generation, while seven countries derive less than 5% of their electricity from oil (Figure 1-16). Oil-based electricity tends to be expensive relative to power generated from coal, gas and hydropower.

Finally, countries' net energy imports as a proportion of total energy use gives an indication of how easily they can switch from imported oil to domestic alternative energy sources. The two former Soviet Republics plus Benin are the most dependent on energy imports, while six countries in the sample rely on imports for less than a fifth of their energy consumption, and the average dependency is 20%. Mozambique is the only LIC that is a net exporter of energy, thanks to its exports of hydropower and coal, which can provide a buffer to offset high oil prices.

Table 1-1 opposite presents indicators of oil vulnerability in 2011 and 2008, based on the formula derived in the introduction to Part 1. The primary measure of oil vulnerability is expenditure on oil (calculated by multiplying annual oil consumption in barrels by the average crude oil price) expressed as a percentage of GDP. In 2011, when the Brent crude oil price averaged $111 per barrel, the average oil vulnerability of LICs was 8% of GDP (and the median, 7%). However, there was considerable variability, from 2% or less in Afghanistan, Cambodia, Mali and Niger, to 12% or more in Benin, Guinea-Bissau, Liberia, Mauritania, Sierra Leone, Tajikistan and Togo. According to the calculations, the latter two countries spent more than a quarter of GDP on oil in 2011. Compared to 2008, when Brent crude oil averaged $97 per barrel, oil vulnerability had increased in 12 countries, declined in 9 countries (as a result of reduced oil consumption and/or appreciating currencies), and remained the same in 10 countries. The average and median oil vulnerability remained constant between 2008 and 2011.

A second component of oil vulnerability is oil import dependence, calculated as the share of oil imports in total oil consumption. In 2011, the average for LICs was an extremely high 95%, although down marginally from the 98% average recorded in 2008. The two exceptions were Niger (0%), which ramped up oil production to meet all its needs in 2011, and Mauritania, which managed to supply 37% of its oil needs. Two further components of oil vulnerability can be calculated for 2008, namely oil intensity (oil consumption as a percentage of total energy consumption) and energy intensity (energy use per dollar of GDP). Average oil intensity in LICs was 71% in 2008, but there was a high degree of variability: oil intensity was extremely high (over 90%) in 13 countries, and over 50% in 23 out of the 31 countries. Oil intensity was less than 20% in just two countries, namely Mozambique and Zimbabwe (which both have domestic coal reserves and produce hydropower).

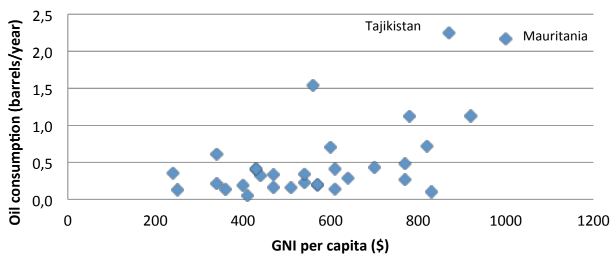
Table 1-1: Oil vulnerability indicators for LICs

INDICATOR	OIL VULNERABILITY		OIL IMPORT DEPENDENCE		OIL INTENSITY
UNITS	%		%		%
YEAR	2011	2008	2011	2008	2008
Afghanistan	1	1	100	100	46
Bangladesh	4	4	95	93	23
Benin	16	13	100	100	95
Burkina Faso	4	4	100	100	91
Burundi	5	3	100	100	67
Cambodia	1	12	100	100	97
Central Afr. Rep.	4	4	100	100	80
Comoros	7	7	100	100	99
Eritrea	9	13	100	100	100
Ethiopia	6	6	100	100	75
Gambia, The	7	10	100	100	100
Guinea	7	8	100	100	79
Guinea-Bissau	12	11	100	100	100
Haiti	7	9	100	100	95
Kenya	10	8	100	100	76
Kyrgyz Republic	11	10	94	94	17
Liberia	14	17	100	100	100
Madagascar	10	7	100	100	84
Malawi	6	6	100	100	48
Mali	2	2	100	100	77
Mauritania	13	8	63	39	99
Mozambique	7	5	100	100	16
Nepal	4	5	100	100	49
Niger	0	2	0	100	53
Rwanda	4	4	100	100	91
Sierra Leone	18	18	100	100	99
Tajikistan	27	25	99	99	27
Tanzania	7	6	100	100	58
Togo	29	21	100	100	93
Uganda	4	3	100	100	63
Zimbabwe	4	10	100	100	16
Average	**8**	**8**	**95**	**98**	**71**
Median	**7**	**7**	**100**	**100**	**79**
Std. Deviation	**7**	**6**	**19**	**11**	**29**

SOURCE: Own calculations based on EIA (2012) and World Bank (2012)

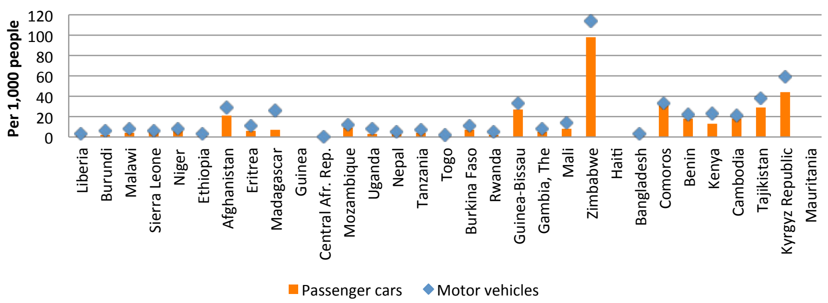
*NOTE: *Energy use (consumption) as defined by the EIA (2012) excludes consumption of combustible renewables and waste (i.e. biomass fuels such as wood, dung and crop residues). Thus the oil intensity figures presented here refer to the proportion of modern energy derived from oil.*

Figure 1-17: Gross national income per capita and oil consumption per capita in LICs



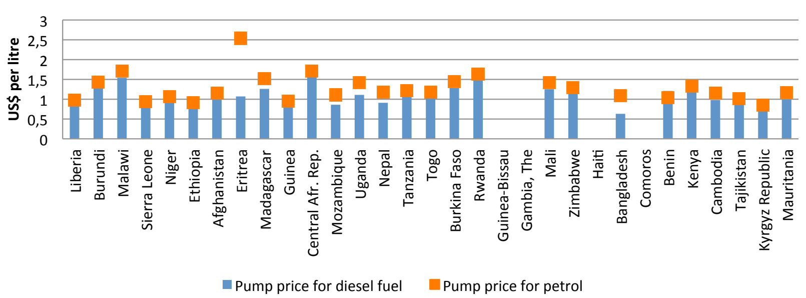
SOURCE: Own calculations based on EIA (2012) and World Bank (2012)

Figure 1-18: Motor vehicle prevalence in LICs



SOURCE: World Bank (2012)

Figure 1-19: Diesel and petrol prices in LICs, 2010



SOURCE: World Bank (2012)

Figure 1-17 displays the relationship between income per head and oil consumption per capita (barrels per year) for the LICs. Although the correlation (0.6) is not very strong, there is a discernible positive relationship, i.e. oil consumption tends to be higher in countries with higher average incomes. The main outlier is Mauritania, which attained the highest income and oil consumption per capita – and this was partly due to the country's own oil production, which met a third of total oil consumption. Mauritania was in fact until 2010 in the World Bank's lower middle income category.

Road transport indicators

The average numbers of motor vehicles (19) and passenger cars (13) per 1,000 people are, as is to be expected for low income societies, very low (Figure 1-18). The outliers amongst this sample are Zimbabwe, Kyrgyz Republic and Tajikistan, whose economies were all significantly wealthier prior to their economic collapses in the 2000s (Zimbabwe) and 1990s (the former Soviet Republics). Road sector energy consumption is generally a very small percentage of total energy consumption (average = 9%; median = 6%), with the exception of Benin (27%) and Kyrgyz Republic (28%). The same is true for road sector energy consumption per capita.

Figure 1-19 displays average fuel prices recorded in LICs in 2010. Pump prices for diesel were rather variable, from a low of $0.63/litre in Bangladesh to a high of over $1.40/litre in the landlocked countries of Malawi, Burundi, Rwanda and Central African Republic. However the price in most countries was clustered around the average of $1.11. The average pump price of petrol (gasoline) was somewhat higher at $1.28. Variations in fuel prices reflect mainly differing subsidies, taxes and transport costs for fuel.

1.2.3 Likely impacts of oil shocks

This section discusses the probable impacts of oil shocks on LICs, first in terms of price shocks, then with regard to supply disruptions or shortages, and finally by focusing on three special categories of country.

Oil price shocks

The stylized macroeconomic transmission of oil price shocks for oil importing countries was outlined in section 1.1.

The balance of payments of LICs is likely to suffer from two effects. First, inelastic demand for oil implies that expenditure on oil imports rises when the international oil price rises. Second, most LICs tend to be heavily dependent on commodity exports, which are highly vulnerable to cyclical decline in demand following the recessionary impacts of oil price shocks on the world economy in general and on the advanced economies in particular. A key variable for the future will be the growth rate in large commodity-importing economies such as China and India, as this will help to determine the terms of trade for commodity-dependent LICs (the stronger the demand for LIC exports from the Asian countries, the better the LIC terms of trade will be). Oil price shocks usually result in deteriorating terms of trade for LICs and can precipitate a depreciation of the real exchange rate (see AfDB, 2009).

In general, an oil price shock is expected to impact negatively on GDP growth as net imports increase. However empirical research shows that the issue is more complicated. For example, "GDP data actually supports the view that the aggregate output performance of most African countries has not been as seriously affected as expected by the impact of higher oil prices" in the period between 1999 and 2006 (AfDB, 2009: 131). Rasmussen and Roitman (2011) analysed the relationship between oil prices and macroeconomic indicators including GDP growth for a sample of 125 oil importing developing countries. These authors found a positive contemporaneous correlation between oil prices and GDP in the majority of countries. Some of the factors that lead to a rise in oil prices (e.g. rapidly growing world demand) can also produce a boom in many other commodity prices, which tends to benefit developing countries – including many LICs – that are commodity exporters. However, in the year following an oil price shock, the authors find that GDP turns negative in a majority of developing countries, although not for LICs. Rasmussen and Roitman (2011) find that the negative output effect is larger in countries with greater oil vulnerability (i.e. greater expenditure on oil imports as a percentage of GDP). It should be noted, however, that after controlling for demand drivers that boost the world economy (in addition to oil prices), Rasmussen and Roitman (2011) do find that oil shocks negatively affect output in oil importing countries. Their results suggest that on average, "a 25% increase in oil prices will typically cause a loss of real GDP in oil-importing countries of less than half of 1%, spread over 2 to 3 years." Nevertheless, other research by the World Bank showed that LICs experienced the greatest proportionate decline in GDP following an oil price shock (Bacon, 2005), so the evidence is mixed. After global oil production enters its decline phase, we can expect global demand conditions to be less advantageous, and supply side oil shocks will become the norm rather than demand shocks with their compensating benefits.

Presuming that governments allow full or partial pass-through of higher international oil prices to the domestic economy, oil price shocks are also expected to raise the rates of producer and consumer price inflation, other things being equal. Higher oil prices lead to higher electricity prices (in countries that produce a significant portion of their power from oil) and higher transport costs, which in turn are often passed on by producers in the form of increased prices for consumer goods and services. While inflation rates declined in many developing countries in the period 2000-2006 (see AfDB, 2009: 134), the severe oil price shock of 2007-2008, which also contributed to soaring food prices, boosted inflation rates in many countries (Brown, 2010).

In response to oil price shocks, LIC governments face a trade-off: if they choose to subsidise fuel prices in an effort to shield consumers from the negative socioeconomic impacts of higher fuel prices and thus avoid social opposition, then they are likely to experience tightening fiscal constraints on other areas of social spending (AfDB, 2009: 124). Empirical results of a modelling exercise conducted by African Development Bank researchers showed that the effect of fuel subsidies on government budget deficits could be very severe, and also have a large, negative knock-on impact on consumer spending (AfDB, 2009: 143). Another potential negative impact of an oil price shock on LICs is that countries which rely heavily on foreign aid (e.g. monetary transfers, food aid, and medical supplies) may find that such aid flows are curtailed as developed country donors suffer recessionary effects of the oil shock. Governments that do try to lean against the winds of higher oil prices risk incurring soaring debt levels, which could reach crisis proportions in those countries that are already heavily indebted. Indeed, many low income countries became engulfed in the so-called Third World Debt crisis after interest rates in the industrialised countries rose sharply in the early 1980s after the second oil shock. LICs' lack of financial sophistication is a double-edged sword. On the one hand, they lack access to international credit markets (AfDB, 2009: 123), which shuts off one possible avenue for coping with a transient oil price shock. On the other hand, LICs face a low risk of financial contagion from developed or emerging market nations.

The prices of agricultural commodities on international markets are related to oil prices both directly because of rising input and transport costs, and also indirectly because of the incentives to produce biofuels from food crops or using arable land that could have supported food production (FAO, 2008: 10; Brown, 2012). As Brown (2012: 40) states, "The capacity to convert enormous volumes of grain into fuel means that the price of grain is now more closely tied to the price of oil than ever before." Indeed, the oil price spikes of 2007-2008 and 2010-2011 were accompanied by spikes in the prices of many basic agricultural commodities such as maize, wheat and rice. These price spikes were exacerbated by steps taken by governments in some countries to lower domestic food prices and safeguard food security by imposing limitations or outright bans on the export of certain staple commodities (FAO, 2008: 11; IMF, 2012). A repeated confluence of these factors in the future could constrain low income countries' ability to import agricultural products. At the very least, it is highly likely that future oil price shocks will result in food price spikes as well.

When it comes to socioeconomic impacts, the poorest households tend to experience the greatest hardships as a result of oil price shocks, as they spend a relatively larger percentage of their incomes on energy (e.g. paraffin for lighting, cooking and heating), and transport and food, whose prices are heavily influenced by transport costs (Bacon, 2005). Hence oil price shocks can broaden and deepen the endemic poverty in LICs (AfDB, 2009: 136). As noted in section 1.2.1, income inequality is not a major problem in most LICs – mainly because a relatively wealthy middle class has yet to emerge and the vast majority of the population is poor. To the extent that social cohesion is undermined by inequality, especially in the face of shocks, LICs might be relatively well off. However if the shock is too severe for a large part of the poor population to cope with, there could be very adverse results for social and political stability. This is particularly likely if food security is undermined by rising food prices and reduced food aid flows from abroad (Brown, 2012: 40).

Oil supply shocks

The impacts of physical oil supply shocks – that is, shortages of crude oil and/or refined petroleum products – can be even more intense than price shocks. Possibly the most damaging potential impact of oil supply disruptions is on countries which rely heavily on oil to generate electricity. Severe power shortages can result in serious social problems within a matter of a few days, such as food shortages, water treatment and supply problems, public health crises in hospitals and clinics, breakdown of telecommunications systems, and so on. Even limited power shortages can have very adverse consequences for industrial production and commerce, as well as causing inconvenience for residential consumers.

Fuel shortages obviously have a large impact on motorised transport systems, which even in LICs are highly dependent on petroleum fuels. In the rural areas of LICs, and in urban areas where the majority of people rely on non-motorised transport, fuel shortages would have a more muted effect than in countries where more people rely more on motorised transport, for example to access places of work and food. Since comparatively few people in LICs enjoy access to private motor vehicles and to an extent public motorised transport, the impact of fuel shortages on personal mobility will not be extensive for large parts of the populations of these countries.

Economic activities that require freight movement by trucks, diesel-powered trains and ships would also be disrupted by fuel shortages. Informal sector economic activities, especially services and small-scale production using local inputs, would be less affected by fuel shortages. Agricultural activity is also likely to be relatively less affected by fuel shortages in LICs compared to wealthier countries as the majority of farmers use traditional methods rather than fossil fuel intensive, mechanised production methods. Nonetheless, by restricting freight movement, protracted fuel shortages would negatively impact on exports of primary agricultural produce in commodity-exporting nations. While fuel shortages would no doubt cause extra hardship for city-dwellers, many of those living in rural areas may be less affected, unless they rely on deliveries of food or other forms of aid by road transport. Subsistence farmers would be largely unaffected by short-term oil shocks.

Special country categories

Finally, three special categories of countries, which cross-cut the income categories, warrant a separate mention: landlocked countries; Small Island Developing States (SIDS); and fragile and conflict affected states (see IMF, 2011). Seventeen of the 31 LICs in the sample have coastlines and at least one port city or town. This enables them to trade more easily and cheaply with foreign countries, as shipping is the cheapest mode of freight (Rubin, 2009). The remaining 14 LICs are **landlocked countries,** *viz*. Afghanistan, Burkina Faso, Burundi, Central African Republic, Ethiopia, Kyrgyz Republic, Malawi, Mali, Nepal, Niger, Rwanda, Tajikistan, Uganda and Zimbabwe (see Table 03). These landlocked nations face special difficulties in dealing with oil shocks, as transport costs for land-borne traded goods are considerably higher than those of sea-borne goods (Gilbert & Perl, 2008). Diesel prices were on average 14% higher in landlocked countries than non-landlocked nations in 2010, and petrol prices 4% higher, reflecting in part the greater costs of transporting fuels inland. Apart from Niger, all of these countries were almost entirely dependent on oil imports in 2011. In addition, with the exception of the Kyrgyz Republic none of the landlocked LICs has oil refining capacity, and they are therefore completely dependent on imports of refined petroleum fuels and have limited fuel storage capacities. In times of generalised fuel shortages, these countries are likely to experience more acute difficulties in obtaining fuel supplies than countries with refining capacity, since they are at the end of the petroleum supply chain.

The second special category is the **Small Island Developing States** (SIDs), of which there are three amongst the sample of 31 LICs, namely Comoros, Guinea-Bissau and Haiti. All three countries have 100% oil import dependency ratios. Moreover, as with their landlocked LIC cousins, these countries have no petroleum refining capacity, and are therefore at the vulnerable end of the petroleum supply chain. As some of the poorest countries in the world, they lack the political or economic clout that could help to ensure adequate fuel supplies in times of oil scarcity. The fuel imports of Comoros, which lies off the eastern coast of Africa between Mozambique and Madagascar, might also be vulnerable to piracy, which has expanded south from the coast of Somalia in recent years (McNeish, 2011).

The third special category, which is especially relevant to LICs, comprises **fragile and conflict affected states** (FCS), which are characterised by weak state capacity and/or legitimacy (IMF, 2011; World Bank, 2012c). Stewart and Brown (2009) suggest that "states may be fragile because they lack authority (authority failure), fail to provide services (service entitlement failure) or lack legitimacy (legitimacy failure)." According to the World Bank (2011), the following net oil importing LICs are characterised as fragile or conflict affected: Afghanistan, Burundi, Central African Republic, Guinea, Guinea-Bissau, Haiti, Liberia, Sierra Leone, Somalia, and Togo. Citizens in FCS are particularly vulnerable, as their governments lack either the capacity or the willingness to adequately ameliorate the impact of socioeconomic shocks, including oil price and supply shocks.

1.2.4 Summary

In term of their **socioeconomic characteristics**, low income countries in general share a number of similarities that increase their vulnerability to oil shocks, including:

- comparatively undiversified economies, with a high degree of reliance on world trade for both commodity exports and manufactured imports;
- very high rates of poverty and undernourishment; and
- moderate to large current account deficits and external debt to GDP ratios.

On the other hand, some general characteristics of LICs could help to shield them from oil shocks, namely:

- a high degree of reliance on traditional biomass fuels;
- a relatively large agriculture sector, much of which is subsistence;
- low energy intensity per capita and per GDP;
- relatively low levels of income inequality and unemployment;
- a relatively low urbanisation rate; and
- extremely low prevalence of motor vehicles and a small share of total energy consumption devoted to the road sector.

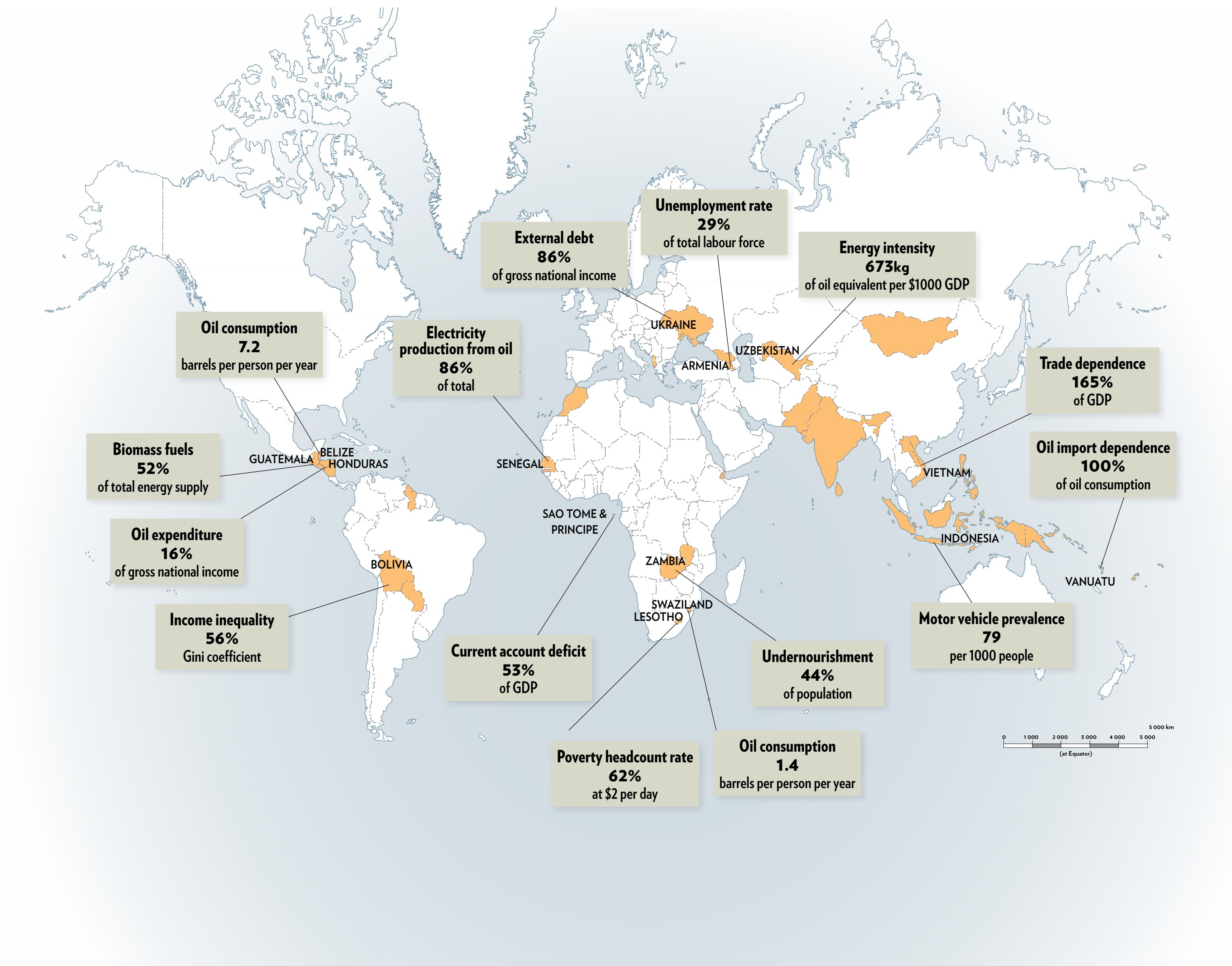
The data have also shown that there is a high degree of variability among the group of 31 LICs for some indicators, such as the size of external debt and foreign exchange reserves, population size and density, rates of dependence on oil for electricity generation, and reliance on energy imports to meet overall energy needs. With respect to oil vulnerability indicators, in most of the LICs (and on average for the group), the data showed that:

- oil vulnerability is moderately high (an average of 8% of GDP is spent on oil);
- oil resource dependency is extremely high (averaging 95% in 2011); and
- oil import intensity is very high (averaging 71% in 2008).

The main oil shocks impacts that are expected for LICs include:

- deteriorating balance of payments and terms of trade;
- a decline in production and hence GDP growth;
- a rise in producer and consumer price inflation;
- a broadening and deepening poverty and food insecurity, possibly resulting in social upheaval.

1.3 Lower Middle Income Countries



This section analyses the major oil dependencies and likely vulnerabilities to and impacts of oil price and supply shocks on lower middle income countries (LMICs). LMICs are defined by the World Bank as those countries with gross national income (GNI) per capita of between $1,026 and $4,035 in 2011. The analysis is based largely on data drawn from the World Bank (2012) Development Indicators and U.S. Energy Information Administration, for a sample of 37 countries. Data were not available for all indicators for all countries. The following subsections present the key socioeconomic characteristics of these countries, analyse various indicators of oil vulnerability, and discuss the probable impacts of oil shocks.

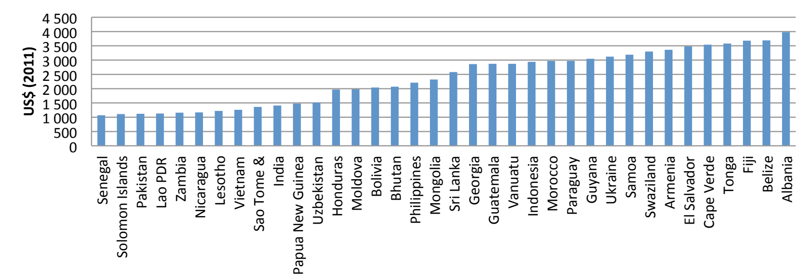
1.3.1 Key socioeconomic characteristics

We begin by presenting key data on economic, socioeconomic and demographic characteristics of lower middle income countries, which provide contextual data to evaluate countries' vulnerabilities and/or capacities to adapt to oil price and supply shocks.

Economic indicators

The sample of 37 LMICs includes several fairly large economies, notably India ($1,746 billion), Indonesia ($713 billion), the Philippines ($209bn) and Pakistan ($198) – all of which have very large populations. However the majority of LMIC economies are small in absolute terms (over 80% had a GNI of less than $100,000 in 2011). Annual GNI per capita averaged $2,378 in 2011, while the median income per head was $2,450 (Figure 12-0). At the bottom end of the income scale were Senegal ($1,070), Solomon Islands ($1,110), Pakistan ($1,120), Lao PDR ($1,130), Zambia ($1,160) and Nicaragua ($1,170). The wealthiest members of the group were Albania ($3,980), Belize ($3,690), Fiji ($3,680) and Tonga ($3,580).

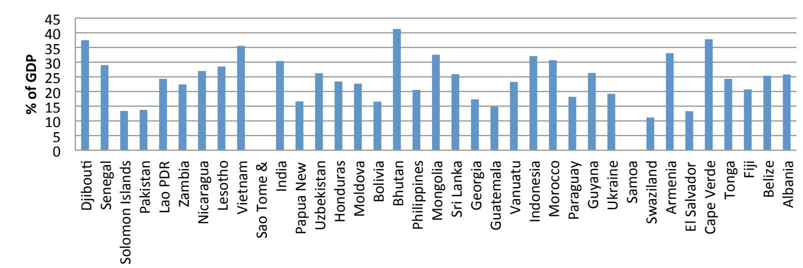
Figure 1-20: Gross national income per capita in LMICs, 2011



SOURCE: World Bank (2012)

The levels of income attained by the LMICs afford them a relatively limited capacity to respond to oil price shocks, although in recent years some of these countries have been experiencing rapid economic growth and development (especially India), which has provided some flexibility in terms of the kinds of investments they have been able to make. This is reflected in the fact that LMICs are characterised in general by a relatively high average gross fixed capital formation as a percentage of GDP, namely 25% in 2010. In eight of the countries, GFCF was at least 30% of GDP, while only three countries recorded ratios of less than 15% (Figure 1-21). High rates of investment could be used to reduce oil dependency by investing in alternative energy and transport infrastructure.

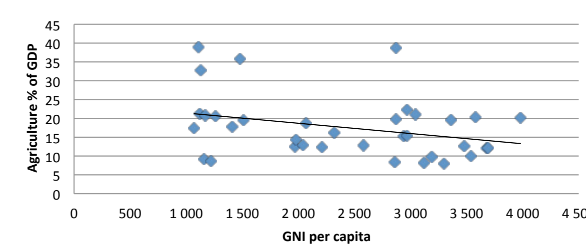
Figure 1-21: Gross fixed capital formation in LMICs, 2010



SOURCE: World Bank (2012)

LMICs have begun the transition from agrarian to industrial economics, as evidenced by the smaller share of agriculture (17% on average) relative to industry (29%) and services (54%) in GDP. The share of industry is particularly large in many of these LMICs: over 40% in five countries (Bhutan, Indonesia, Papua New Guinea, Swaziland and Vietnam). Within the LMIC sample, there is a weak inverse relationship (a correlation coefficient of -0.31) between the share of agriculture and GNI per

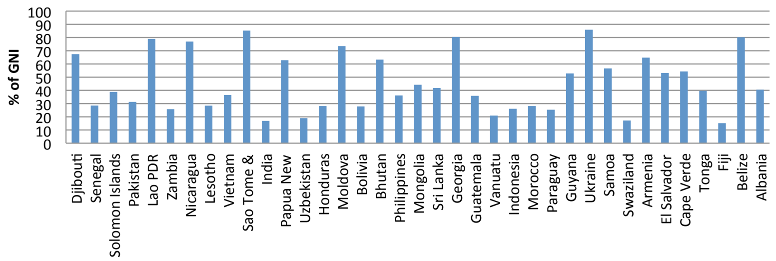
Figure 1-22: Gross national income per capita and agriculture's share of GDP in LMICs



SOURCE: World Bank (2012)

capita, as could be expected (Figure 1-22). The outlier in this group is Gautemala, which has a much higher share of agriculture than its income peers.

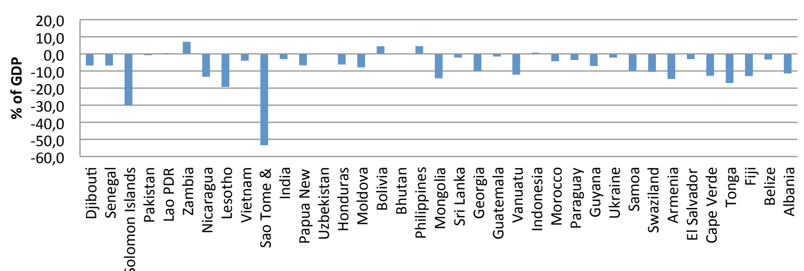
Figure 1-23: **External debt stocks in LMICs, 2010**



SOURCE: World Bank (2012)

Several balance of payments indicators show countries' vulnerability to the macroeconomic impacts of oil price shocks. The average size of external debt as a percentage of GNI is 46%, while the median is somewhat lower at 40%. Four countries have dangerously high external debt ratios of greater than 80%, namely Belize, Georgia, Sao Tome and Principe, and Ukraine (Figure 1-23). On the other hand, debt ratios are quite low in countries such as Fiji (15%), Swaziland (17%), India (17%) and Uzbekistan (19%). Highly indebted countries are particularly susceptible to rises in world interest rates, which often occur in the wake of oil price shocks as central banks move to counter inflationary pressures. Interest payments on external debt as a percentage of GNI averaged just 1% in 2010, a time of record low global interest rates as economies struggled to recover from the global recession. The average level of foreign exchange reserves expressed as a percentage of external debt stood at 66% in 2010 (and the median was 55%). Eight countries in this sample have reserves in excess of their external debt, and are therefore relatively well placed to weather balance of payments shocks, but fifteen LMICs have reserves that cover less than half of their external debts.

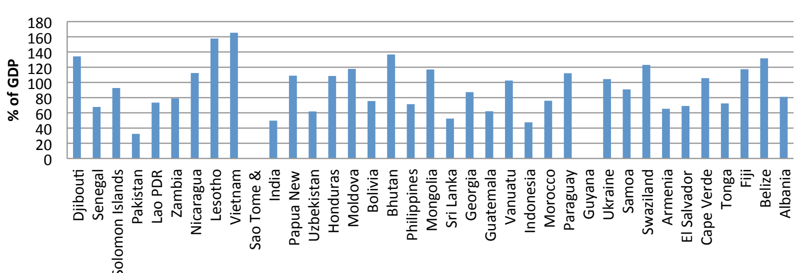
Figure 1-24: **Current account balances in LMICs, 2010**



SOURCE: World Bank (2012)

Only five of the 37 LMICs in the sample ran current account surpluses in 2010, namely Bolivia, Indonesia, Lao PDR, Philippines and Zambia (Figure 1-24). The largest deficits (as a percentage of GDP) were recorded by Small Island Developing States, viz. Sao Tome & Principe (-53%) and Solomon Islands (-30%). The average current account balance was a deficit of 8.4%, and thus the majority of the LMICs are very vulnerable to balance of payments shocks and run the risk of rapid exchange rate depreciation in the event of an oil price shock.

Figure 1-25: **Trade as a percentage of GDP in LMICs, 2010**



SOURCE: World Bank (2012)

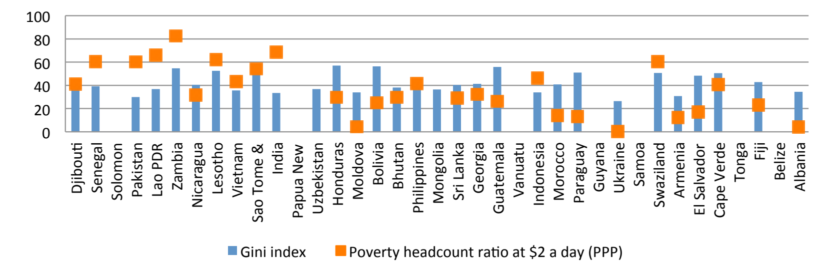
LMICs as a group are highly dependent on international trade, as evidenced by the average trade to GDP ratio of 93% in 2010 (Figure 1-25). The largest proportionate traders were Vietnam (163%) and Lesotho (158%), followed by other small economies including Belize, Bhutan, Djibouti and Swaziland. The landlocked nations in this grouping (e.g. Lesotho, Swaziland and Bhutan) are particularly vulnerable to rising transport costs, which will negatively affect their

trade balances. There is only a weak negative correlation (-0.36) between size of economy (GNI) and trade as a percentage of GDP, so it is not only small countries that rely heavily on trade.

Socioeconomic indicators

Income inequality for the LMIC group, as measured by the average Gini coefficient of 42, is moderate. Inequality is highest (with a Gini index above 50) among several Latin American nations (Bolivia, Guatemala, Honduras and Paraguay), three southern African countries (Swaziland, Lesotho and Zambia), and two SIDS (Cape Verde, and Sao Tome and Principe) (Figure 1-26). Ukraine (26), Pakistan (30) and India (33) are among the most egalitarian societies in this sample, and are therefore likely to experience less social conflict arising from oil-related economic shocks than more unequal societies, other things being equal. On average, the richest 20% of citizens earn almost half of the income in LMICs. Poverty rates are significant in many LIMCs, although not as severe as in LICs. The average poverty headcount rate at the $1.25/day measure is 18%, while at the $2/day benchmark the rate is twice as high (36%). Broad poverty rates are very high in the large, populous nations of India (69%) and Pakistan (60%), which presents a formidable challenge to these states in the face of oil shocks (Figure 1-26). In contrast, poverty is practically non-existent in the former socialist countries of Ukraine, Moldova and Albania. There is only a weak association (a correlation coefficient of 0.4) between extreme poverty and income inequality in this sample; generally inequality becomes more significant when incomes begin to rise and a middle class emerges.

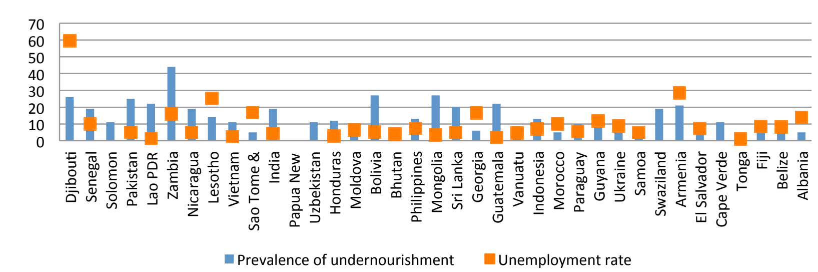
Figure 1-26: **Gini index and poverty headcount ratio in LMICs**



SOURCE: World Bank (2012)

Undernourishment afflicts on average 14% of the population in LMICs, although the rate is over 20% in eight countries, including Pakistan and Sri Lanka (and 19% in India). Undernourishment is moderately correlated (0.63) with extreme poverty. Joblessness is not a major problem in the majority of the LMICs, with a median unemployment rate of 7% (and an average of 10%). The main outlier is Djibouti, which recorded an extremely high unemployment rate of 60% in 2010. Unemployment is also a large problem in Armenia (29%) and Lesotho (25%), but the jobless rate is less than 10% in the majority of the sample. The unemployment rate is not at all correlated with either measure of poverty, presumably because large segments of

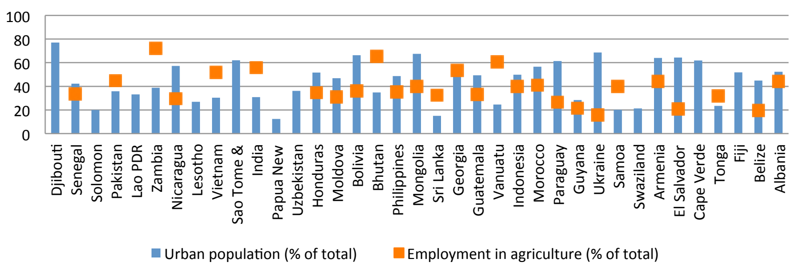
Figure 1-27: **Prevalence of undernourishment and unemployment in LMICs**



SOURCE: World Bank (2012)

the poor in LMICs are engaged in subsistence agriculture and are therefore not counted among the unemployed. Subsistence farmers can be undernourished if they are unable to produce enough food to meet their dietary needs.

Figure 1-28: Urbanisation rate and employment in agriculture, LMICs



The LMIC sample includes several very populous nations (India, Indonesia, Pakistan, Philippines and Vietnam, each having more than 80 million citizens), but 24 of the 37 countries have populations under 10 million, including 10 under 1 million (mostly SIDS). Population density averages 104 people per square kilometre, although the median (68) is somewhat less, indicating the presence of some outliers. The populous Asian countries tend to have amongst the highest population densities. As mentioned in section 1.2, there is a trade-off between the economic benefits of people living clustered closer together (e.g. lower transport distances and costs) and the possible resource-related social pressures that dense living conditions can produce. The percentage of the population living in urban areas is 44% on average in the LMIC sample, although there is considerable variation from lows of 12% (Papua New Guinea) and 15% (Sri Lanka) to highs of 77% (Djibouti) and 69% (Ukraine) (Figure 1-28). Interestingly, there is no correlation between population density and rate of urbanisation in this sample, indicating that rural densities are high in a number of countries. Agriculture remains a very important source of livelihoods in many LMICs, with an average (median) of 39% (36%) of workers employed in this sector (Figure 1-28). Industry accounts for a much smaller share of jobs (18%), while services (41%) comprise the remainder. Agriculture is particularly important for employment in Zambia (73%), Bhutan (65%) and India (56%).

1.3.2 Oil dependencies and vulnerabilities

We turn now to the more direct vulnerabilities of LMICs to oil shocks, which are related to the degree of dependence on oil imports. This section discusses energy indicators, oil production and consumption figures, measures of oil vulnerability, and indicators of transport sector oil dependence.

Energy indicators

The average level of energy consumption per capita among the LMICS was 619 kilograms of oil equivalent per year in 2009. There was, however, a high degree of variability, ranging from lows of under 200 kg/capita in Djibouti, Solomon Islands and Vanuatu, to highs of over 1,000 kg/capita in Mongolia, Ukraine and Uzbekistan (Figure 1-29).[9] The energy intensity of LMIC economies was highly correlated (0.78 coefficient) with per capita energy use, and also very variable around an average of 181 kg of oil equivalent per $1,000 of GDP (at constant 2005 purchasing power parity prices).

Figure 1-30 displays the relationship between energy intensity (Btu per dollar of GDP) and GNI per capita. Clearly, there is no pattern in the data (and this is confirmed by the correlation coefficient of -0.14). The outlier is Uzbekistan, which whose high degree of energy intensity is a legacy from the Soviet era.

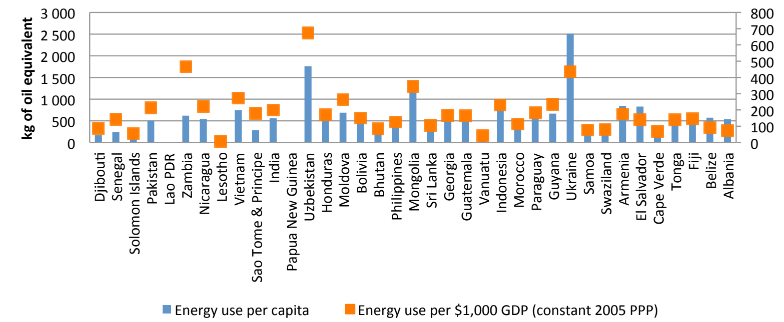
The percentage of the population with access to electricity varies from lows of 16% in Lesotho and 19% in Zambia to highs of 97% in Paraguay and Morocco and 98% in Vietnam (Figure 1-31). The average electricity access stood at 69% (and the median at 71%) in 2009. The contribution of "combustible renewables and waste energy" (e.g. wood and dung for cooking and heating) to total energy is under 10% in six of the countries for which there are data, but over 50% in four countries (Zambia, Sri Lanka, Paraguay and Guatemala). The average proportion of energy derived from traditional biomass fuels is 27% and there is a moderate negative correlation (-0.44) with access to electricity, as is expected since the latter is a modern energy source that replaces traditional fuels.

Oil consumption and production

Fourteen of the 37 LMICs were oil producers in 2011, although only India, Indonesia, Uzbekistan and Vietnam produced more than 100,000 bpd. The latter three countries were formerly net oil exporters, before rising domestic consumption overtook stagnant or falling production. Seventeen of the LMICs had domestic crude oil refining capacity in 2011, while the remaining 20 countries face heightened risks of fuel shortages if there are disruptions to or constraints on crude oil supplies. Oil consumption per capita averaged 2.4 barrels in 2011 for the group as a whole, although this varied considerably: from less than one barrel per person per year

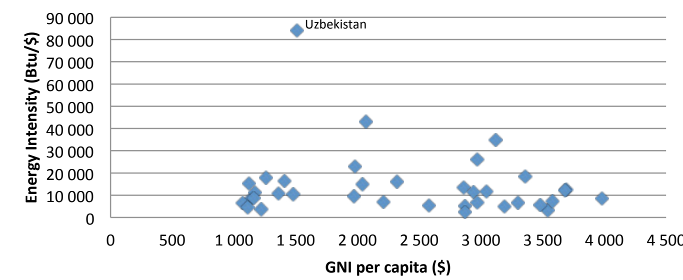
9 The figure for Lesotho (9 kg/capita) appears to be a data error.

Figure 1-29: Energy intensity in LMICs



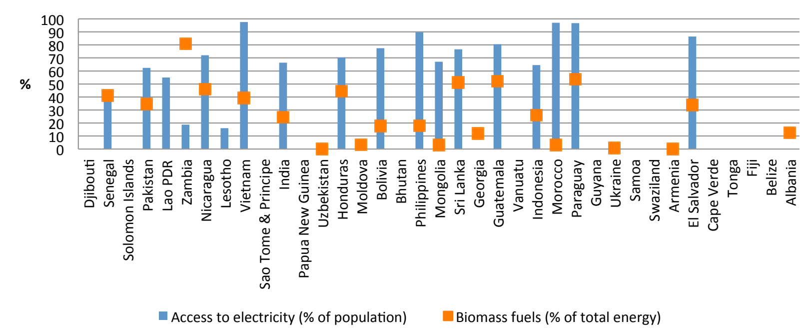
SOURCE: World Bank (2012)

Figure 1-30: Gross national income per capita and energy intensity in LMICs



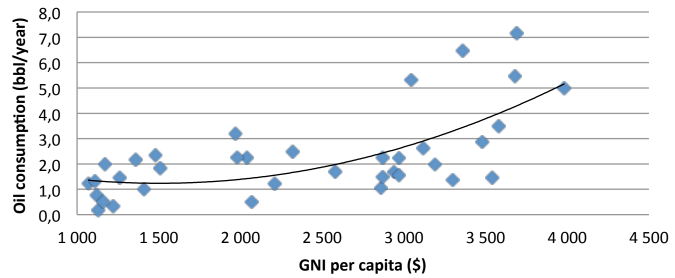
SOURCE: World Bank (2012)

Figure 1-31: Access to electricity and use of biomass fuels in LMICs



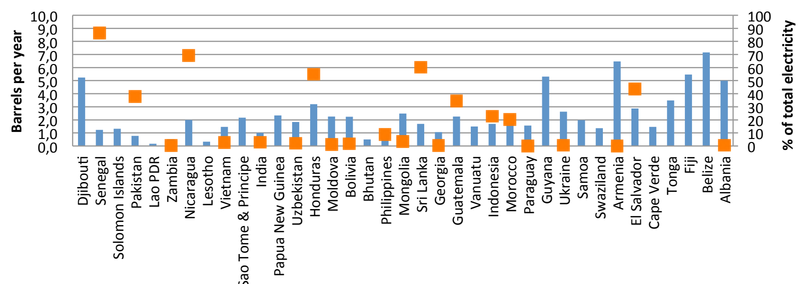
SOURCE: World Bank (2012)

Figure 1-32: Income and oil consumption per capita in LMICs, 2011



SOURCE: Own calculations based on EIA (2012) and World Bank (2012)

Figure 1-33: Oil consumption per capita and electricity production from oil in LMICs



SOURCE: World Bank (2012)

in Bhutan, Lao, Lesotho, Pakistan and Zambia, to over five barrels in five countries. The positive association between GNI per capita and oil consumption per person is shown graphically in Figure 1-32. Oil consumption generally begins to take off when an economic middle class emerges that can afford to buy motor vehicles, and this effect applies only to the wealthier of the LMICs.

Another key use of oil in some countries is for electricity generation. Four countries in the sample (viz. Honduras, Nicaragua, Senegal and Sri Lanka) generate more than half of their power from oil, and are thus highly exposed to oil price and especially supply shocks (Figure 1-33). On the other hand, thirteen of the 20 countries for which data are available derive less than 10% of their electricity from oil, and the average dependence is 21%. Finally, six of the 20 LMICs for which data are available were net energy exporters in 2009, which provides them with a degree of flexibility to substitute alternative energy sources for oil. Moldova and Morocco rely on energy imports to meet over 95% of their energy needs, and are therefore highly vulnerable to energy price or supply shocks.

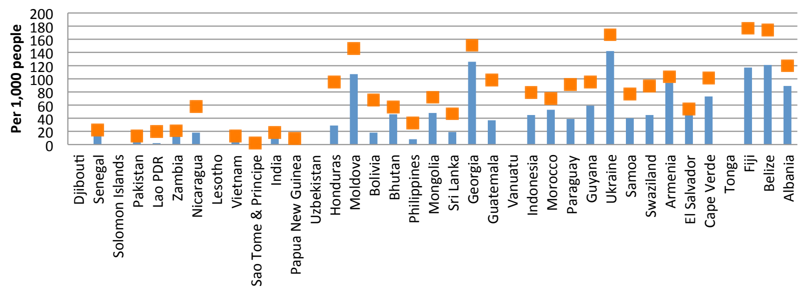
Indicators of oil vulnerability for 2011 and 2008 are contained in Table 1-2. The main measure of oil vulnerability, namely expenditure on oil (i.e. annual oil consumption in barrels multiplied by the average crude oil price) averaged 7% of GDP in 2011, when the Brent crude oil price averaged $111 per barrel. Nine countries spent more than 10% of GDP on oil, and can thus be considered as highly vulnerable to oil price shocks. Eleven LMICs spent less than 5% of GDP on oil. Compared to 2008, when Brent crude oil averaged $97 per barrel, oil vulnerability had increased in 13 countries, declined in 20 countries (which reduced their oil consumption or benefitted from stronger exchange rates), and remained the same in four countries. The average and median oil vulnerability each fell by one percentage point between 2008 and 2011, indicating that GDP grew more than oil consumption in the group as a whole. Oil import dependence (the share of oil imports in total oil consumption) averaged 83% among the LMICs in 2011, up marginally from the 82% average recorded in 2008. Twenty-one of the countries were completely dependent on oil imports, and a further six had over 80% import dependence. Only those countries that were recently net oil exporters had relatively low import dependence (under 50%). Average oil intensity (i.e., oil consumption as a percentage of total energy consumption excluding biomass) in the LICs was 59% in 2008. Djibouti, Guyana and three SIDS (Solomon Islands, Tonga and Vanuatu) use oil for all their modern energy needs. Oil intensity was greater than 50% in 21 out of the 37 countries, and less than 20% in only five countries (Bhutan, Lao, Paraguay, Ukraine and Uzbekistan).

Table 1-2: Oil vulnerability indicators for LMICs

INDICATOR	OIL VULNERABILITY		OIL IMPORT DEPENDENCE		OIL INTENSITY
UNITS	%		%		%
YEAR	2011	2008	2011	2008	2008
Albania	9	7	65	80	57
Armenia	22	14	100	100	46
Belize	8	10	43	53	86
Bhutan	2	5	100	100	6
Bolivia	2	2	19	16	48
Cape Verde	4	5	100	100	99
Djibouti	0	29	100	100	100
El Salvador	9	7	100	100	70
Fiji	14	18	100	100	87
Georgia	3	5	92	95	22
Guatemala	7	5	88	77	68
Guyana	19	20	100	100	100
Honduras	16	13	100	100	78
India	5	6	72	71	30
Indonesia	1	2	11	18	46
Lao PDR	1	2	100	100	14
Lesotho	3	4	100	100	64
Moldova	13	9	100	100	23
Mongolia	6	9	63	82	41
Morocco	8	8	98	98	72
Nicaragua	18	16	100	100	83
Pakistan	6	7	83	84	34
Papua New Guinea	5	-3	33	-24	80
Paraguay	5	6	100	100	13
Philippines	5	6	92	92	51
Samoa	6	7	100	100	81
Sao Tome & Principe	16	17	100	100	94
Senegal	12	10	100	100	89
Solomon Islands	10	8	100	100	100
Sri Lanka	7	8	100	100	81
Swaziland	4	6	100	100	49
Tonga	9	12	100	100	100
Ukraine	6	5	75	70	11
Uzbekistan	4	4	29	24	13
Vanuatu	5	4	100	100	100
Vietnam	1	-1	10	-6	37
Zambia	4	4	99	99	25
Average	**7**	**8**	**83**	**82**	**59**
Median	**6**	**7**	**100**	**100**	**64**
Std. Deviation	**5**	**6**	**29**	**33**	**31**

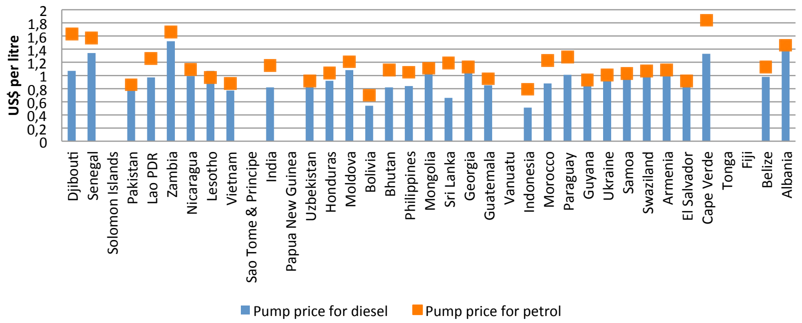
SOURCE: Own calculations based on EIA (2012) and World Bank (2012)

Figure 1-34: Motor vehicle prevalence in LMICs, 2009



SOURCE: World Bank (2012)

Figure 1-35: Petrol and diesel prices in LMICs, 2010



SOURCE: World Bank (2012)

Road transport indicators

The average numbers of motor vehicles (75) and passenger cars (48) per 1,000 people are somewhat higher than in low income societies, but nonetheless reflect the fact that the vast majority of households in the LMICs cannot afford to buy cars (Figure 1-34). Motor vehicle penetration is over 150 per thousand people in Belize, Fiji, Georgia, Moldova, and Ukraine, but very low in populous countries such as Vietnam (13), Pakistan (13), India (18) and Zambia (21). Road sector energy consumption comprises a modest share (17%) of total energy consumption on average, with the highest proportions recorded in Boliva (32%) and Paraguay (27%). Road sector energy consumption per capita follows a similar pattern.

Pump prices for diesel averaged $0.97 per litre in 2010, but varied from lows of $0.51/litre in Indonesia (which until 2004 was a net oil exporter and still subsidises fuel prices) and $0.66 in Sri Lanka, to highs of over $1.40/litre in Albania and landlocked Zambia (Figure 1-35). The pump price of petrol (gasoline) averaged somewhat higher at $1.14, and was correlated quite strongly (0.78) with diesel prices. An outstanding feature of many LMICs (especially those in Asia) is the subsidised prices of diesel and petrol, as governments attempt to promote industrialisation (IEA, 2012a). This policy has the downside of encouraging the growth of oil dependence and militates against energy efficiency.

1.3.3 Likely impacts of oil shocks

We turn now to analyse the possible impacts on LMICs of oil price shocks and oil supply shocks. In general, the impacts are likely to be similar to those described above for LICs as they are based on the same generic macroeconomic transmission mechanism described in section 1.3. However, the higher average level of development will mean that the locus of impact will be somewhat different to the poorer countries. We first consider the macroeconomic and social impacts of oil price shocks, then outline the effects of oil supply shocks, and finally round off the discussion by mentioning the three special categories of country, i.e. landlocked countries, small island states and fragile states.

Oil price shocks

It was noted in section 1.2.3 above that the impact on many developing countries of the cumulative rise in oil prices between 2004 and 2008 was cushioned to an extent by the robustness of the world economy during that period, particularly with regard to demand for commodity exports. However, the global economic conditions that were prevailing in 2011-2012 were far less advantageous: crude oil prices averaged around $110/barrel, compared to $79 in 2007 and $97 in 2008; the industrialised economies of Europe, the U.S. and Japan were still struggling with the after-effects of the Global Financial Crisis and high debt levels; and growth in the emerging power-houses of China and India was cooling notably, especially in late 2012. Thus any further oil price shock in the short- to medium-term is likely to have a greater impact on LMICs (and other countries) than the 2007-2008 shock.

Following from the exposition in the introduction, one of the primary transmission channels for the impact of oil price shocks is via the balance of payments. In particular, LMICs will in general find that their terms of trade deteriorate as oil prices rise, and that their current account balance weakens as well. The magnitude of this effect will of course depend on the specific country's oil vulnerability index. Increased spending on oil imports represents a negative income shock, in the sense that a smaller portion of disposable income is available for spending on other goods and services. Thus for most oil importing LMICs, an oil shock curbs the rate of GDP growth. However, this effect could be offset to a degree in LMICs which export substantial quantities of goods to oil exporting countries, which benefit from windfall oil revenues. Longer term economic growth in LMICs can also be undermined when imports of capital machinery and equipment are foregone in order for fuel imports to be purchased when oil prices are high (Jayaraman and Lau, 2011: 155). The second transmission channel for oil price hikes is via domestic petroleum product prices. Higher petrol and diesel prices will give an inflationary boost to goods and services that rely heavily on oil-based transport, while higher oil prices will raise the costs of petrochemical products. In general, therefore, one expects both producer and consumer prices to rise following an oil price rise.

At a sectoral level, the impacts of oil price spikes in LMICs will depend on the sectoral composition of individual countries. Agriculture in LMICs tends to be a mix of traditional subsistence farming, which has a low reliance on fossil fuels including oil, and an emerging commercial farming sector that uses diesel-powered machinery (in some cases including irrigation pumps) and fossil fuel based fertilisers and pesticides. The latter sector is therefore more susceptible to oil price shocks. As discussed in section 1.2.1, LMICs on average have a fairly high concentration of economic activity in industrial manufacturing sectors, which tend to have a higher energy and oil intensity than services, and are therefore particularly vulnerable to the cost-raising effects of oil price shocks. Nonetheless, there is a considerable degree of variation amongst LMICs in terms of which sectors (e.g. tradable versus non-tradable, mining versus manufacturing) are more prominent. Those that depend heavily on exports of either primary commodities (e.g. Zambia and Nicaragua) or manufactured goods (e.g. Vietnam and Indonesia) could face declining world demand for their exports as the high-consuming countries in the north suffer the negative income effects of the oil shock.

Socioeconomic impacts of oil price shocks will also be significant. Since oil consumption per capita and motor vehicle prevalence are still rather low in LMICs, the impact of oil price spikes on personal mobility will be less severe than in more car-dependent societies with sprawling suburban settlements.

Both non-motorised transport and relatively efficient motorised transport modes (such as motorbikes and scooters) tend to be fairly prevalent in many LMICs, notably several Asian countries. As in LICs, although to a lesser degree, the already high poverty rates will be exacerbated by the impact of oil price rises on the basic cost of living, notably in terms of food, energy and transport costs which comprise a large share of expenditure amongst poorer households. Food insecurity, driven by higher food prices and possibly by job losses, could become a significant problem particularly amongst the large urban poor populations that characterise many LMICs. This in turn could lead to social and political unrest.

Oil supply shocks

Disruptions to the physical supply of oil and refined fuels, although less likely than price shocks (at least in the short- to medium-term), can have greater immediate impacts. As mentioned previously, fuel supply shortages can be devastating for countries that rely largely or entirely on oil for electricity production, since adequate power is essential for most industrial processes and commercial activities, not to mention communications and banking systems. Pakistan, for example, has in recent years experienced the debilitating economic effects of persistent power shortages (albeit due mainly to water shortages curtailing hydropower generation), including lost industrial production and employment. Many social problems are also quick to follow power failures, including health issues and food shortages.

Fuel supply disruptions would have significant impacts on motorised transport systems, which are overwhelmingly dependent on petroleum fuels in many LMICs, with the partial exception of countries that have good electrified railway networks (e.g. India). Freight transport in particular will suffer greatly from fuel shortages, and this will pose major problems for industries that are part of global supply chains and use just-in-time delivery systems. In rural areas and in urban areas where the majority of people rely on non-motorised transport, fuel shortages will not have as dramatic an impact on daily life, but the many commuters who rely on buses will be adversely affected.

Special country categories

The LMIC sample includes eleven **landlocked countries**, *viz.* Armenia, Bhutan, Bolivia, Lao PDR, Lesotho, Moldova, Mongolia, Paraguay, Swaziland, Uzbekistan and Zambia. Fortunately for these countries, they have a very low reliance on oil for electricity production. However, with the exception of Bolivia, Mongolia and Uzbekistan, all of these countries are completely reliant on oil imports. Bolivia, Uzbekistan and Zambia have some oil refining capacity and are perhaps not quite as vulnerable as their peers that are at the end of the fuel supply chain. However, average fuel prices in 2010 were no different in the landlocked group than the coastal group of LMICs.

Amongst our sample of 37 LMICs, there are nine **Small Island Developing States**, namely Cape Verde, Fiji, Guyana, Papua New Guinea, Samoa, São Tomé and Principe, Solomon Islands, Tonga and Vanuatu. A further three SIDS that fall within the LMIC category were excluded from the sample owing to a lack of data (Kiribati, Marshall Islands and Micronesia). With the exception of Papua New Guinea (which met about two thirds of its oil needs in 2011), none of these states produce any oil or other fossil fuels, or possess any oil refining capacity. They are thus entirely dependent on imports of refined fuels. A recent empirical study by Jayaraman and Lau (2011), using panel data for five Pacific SIDS, showed that oil price rises had a negative impact on economic growth and strained the foreign reserves of these nations, at least in the short run. This has in turn made it more difficult for these countries to afford the imports of grains upon which they are almost entirely dependent. Although data on electricity production from oil sources were not available for the LMIC SIDS in the World Bank database, Jayaraman and Lau (2011) report that most of the Pacific SIDS rely mainly on diesel generators. Oil intensity of SIDS economies also tends to be high due to the importance of fuel-intensive industries such as fishing and tourism, and a high degree of reliance on international trade. Transport costs also add a premium to local fuel prices, since in most cases refined fuels are sourced from far away (e.g. Singapore in the case of Pacific SIDS). Most SIDS rely heavily on foreign aid and tourism, but both of these sources of foreign exchange are likely to be constrained in a future of persistent oil scarcity and price shocks. Given these factors, it is not surprising that SIDS (and in particular, Pacific SIDS) have been labelled the most vulnerable countries in the world to oil price shocks (Levantis, 2008).

Thirdly, the LMIC group also includes two **fragile and conflict affected states**, namely the Solomon Islands and Papua New Guinea. As mentioned in section 1.2.3, these nations have limited state capacity and legitimacy, which means the countries' populations have a heightened exposure to economic shocks.

1.3.4 Summary

The empirical analysis of 37 lower middle income countries revealed a marked degree of variability in many of the indicators. Nonetheless, some average **socioeconomic and demographic characteristics** predispose them to oil shock vulnerability, including:

- economies that have a relatively high contribution of (energy-intensive) industry compared to agriculture and services;
- comparatively low levels of foreign reserves in relation to external debt;
- large current account deficits and a high level of dependence on international trade;
- moderately high incidence of poverty and extreme poverty; and
- large urban poor populations.

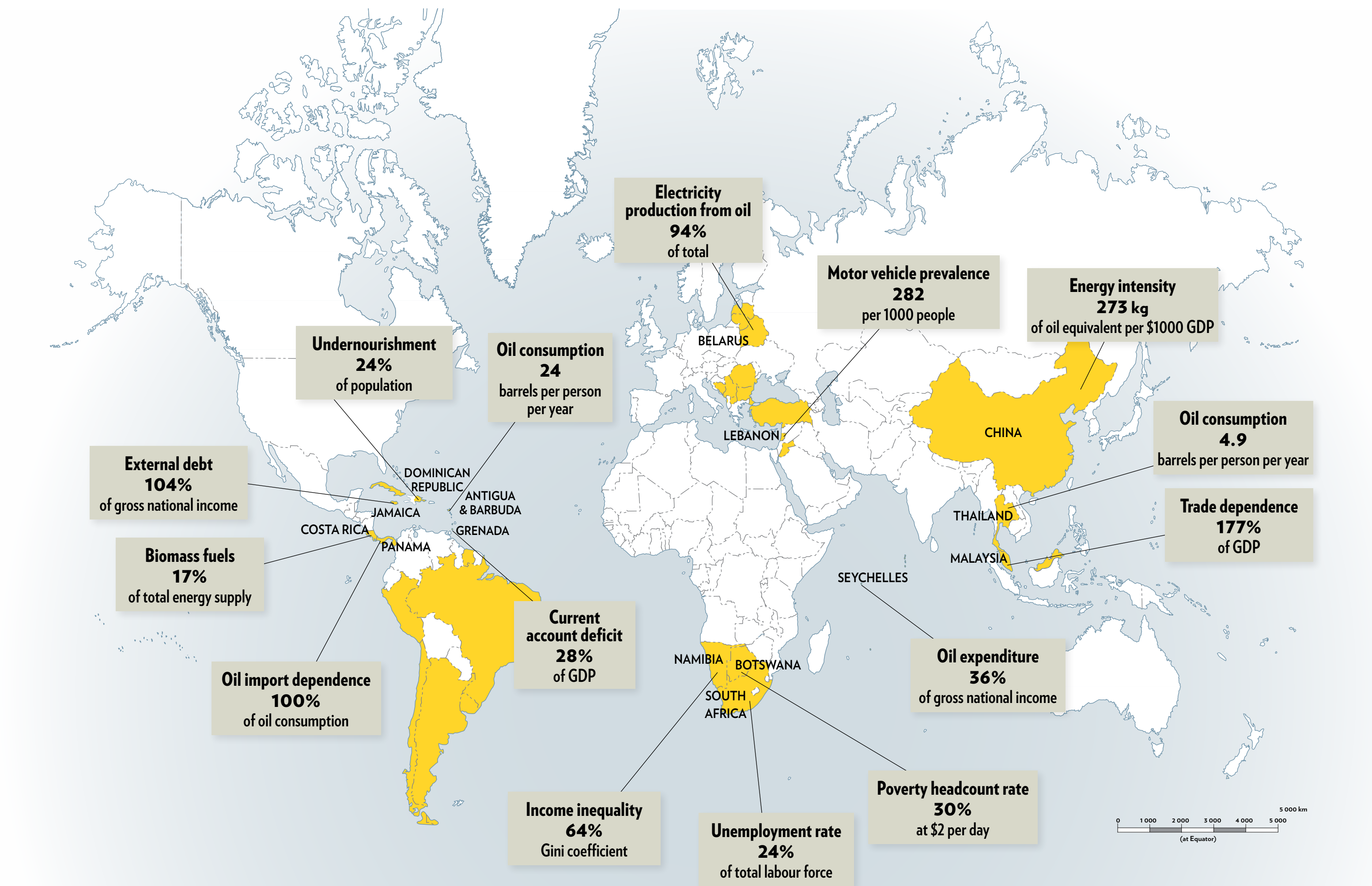
Oil vulnerability will be moderated to some degree in many LMICs by the moderate extent of urbanisation and generally low prevalence of motor vehicles. In terms of energy use indicators, we find that LMICs have highly variables rates of energy intensity, rates of access to electricity, levels of dependence on oil for electricity generation, and reliance on energy imports to meet overall energy needs. The **oil vulnerability** indicators demonstrated that:

- oil vulnerability is moderately high (an average of 7% of GDP is spent on oil);
- oil resource dependency is very high (averaging 83% in 2011); and
- oil import intensity is high (averaging 59% in 2008).

The main **oil shocks impacts** that are expected for net oil importing LMICs include:

- growing current account deficit;
- slowing GDP growth and employment creation;
- a rise in producer and consumer price inflation, especially for transport and food items;
- increasing rates of poverty and inequality; and
- growing food insecurity, possibly undermining social cohesion.

1.4 Upper Middle Income Countries



This section analyses the major oil dependencies and likely vulnerabilities to and impacts of oil price and supply shocks on upper middle income countries (UMICs). Upper middle income countries are defined by the World Bank as those with gross national income (GNI) per capita of between $4,036 and $12,475 in 2011. The analysis is based largely on data drawn from the World Bank (2012) Development Indicators and U.S. Energy Information Administration, for a sample of 37 countries.[10] Data were not available for all variables for all countries. The following subsections present the key socioeconomic characteristics of these countries, analyse various indicators of oil vulnerability, and discuss the probable impacts of oil shocks.

10 Three upper middle income countries, namely Argentina, Malaysia and Suriname, are border-line cases of net oil importer/exporter. According to the EIA (2012) data, they were net oil exporters in 2011, but the BP (2012) database records the former two countries as having become net oil importers in 2011 (no data are given by BP for Suriname). In any event, based on recent trends it seems highly likely that these countries will become net oil importers very soon, as domestic oil production is falling while consumption is rising. Therefore these countries are counted among the net oil importing countries for the purposes of this study.

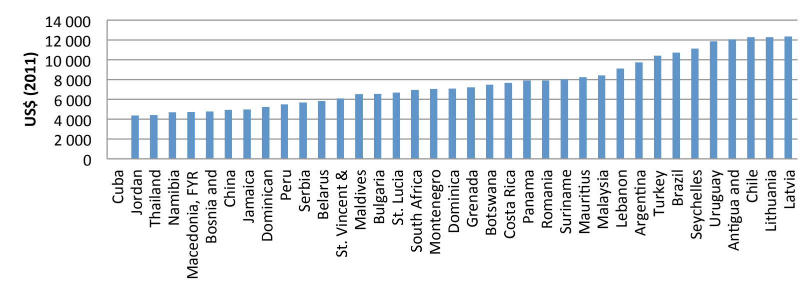
1.4.1 Key socioeconomic characteristics

This subsection discusses important economic, socioeconomic and demographic characteristics of upper middle income countries that have a bearing on their oil shock vulnerabilities.

Economic indicators

The UMICs country grouping includes the economic giants of China (GNI of $6,644 billion in 2011) and Brazil ($2,108bn), both of which rank among the largest 10 economies in the world. A second tier of economies includes the likes of Argentina ($397bn), Chile ($212bn), Malaysia ($243bn), South Africa ($352), Thailand ($307) and Turkey ($766). There are also several very small economies (with GNI at most $2bn), most of which are Small Island Developing States (viz. Antigua and Barbuda, Dominica, Grenada, Maldives, Seychelles, St Lucia, and St Vincent and the Grenadines). On a per capita basis, GNI is highest (above $12,000) in Antigua and Barbuda, Chile, Latvia and Lithuania; average incomes are greater than $10,000 in eight countries altogether (Figure 1-36). At the lower end of the income scale (under $4,000) are Bosnia and Herzegovina, China, Jamaica, Jordan, Macedonia, Namibia and Thailand. Average GNI per capita in the sample is $7,693 and the median income is $7,155. By virtue of the income classification band, the UMIC group has greater absolute variability in incomes than the LMICs and the LICs.

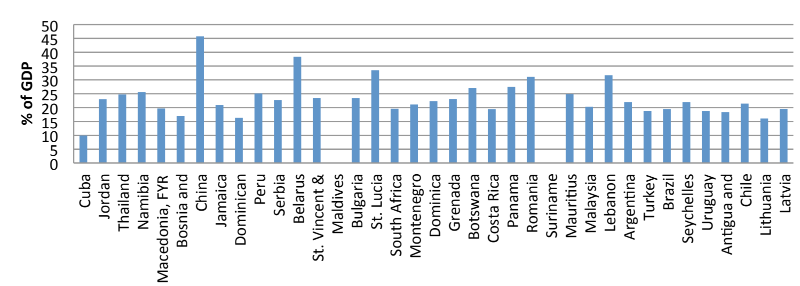
Figure 1-36: Gross national income per capita in UMICs, 2011



SOURCE: World Bank (2012)

Gross fixed capital formation (GFCF) expressed as a percentage of gross domestic product (GDP) averages 23% in the sample, with China (46%) being the only country with a proportion above 40% (Figure 1-37). Cuba is the only country where GFCF is less than 15% of GDP. On the whole, these countries are investing heavily in their industrialisation, which gives them room to choose more sustainable investments that can mitigate future oil shocks. However at present, most of these countries are locking themselves into further oil dependence by building infrastructure such as roads, airports and in some cases oil refineries.

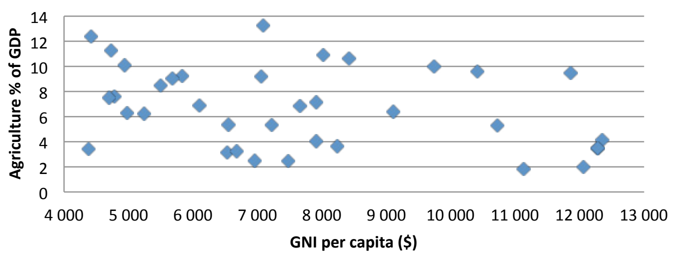
Figure 1-37: Gross fixed capital formation in UMICs



SOURCE: World Bank (2012)

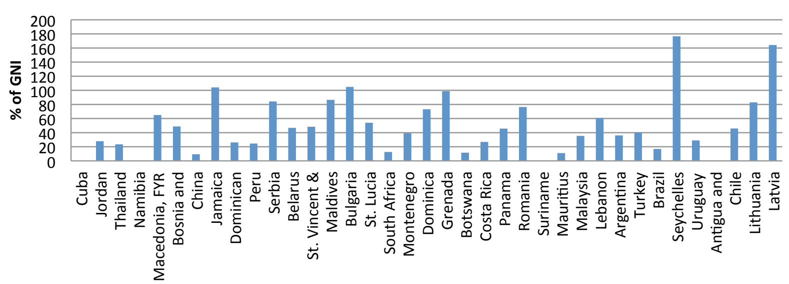
UMICs are well on the road to industrialisation, as indicated by the relatively small share of agriculture in GDP, which is 7% on average and less than 10% in all but eight of the countries. Industry on average contributes 28% to GDP, while services are dominant overall with a 66%

Figure 1-38: Gross national income per capita and agriculture's share of GDP in UMICs



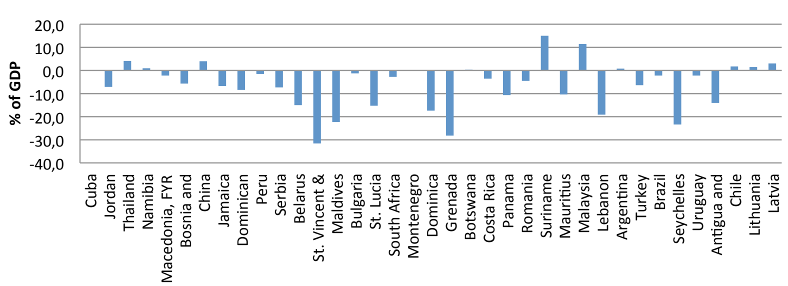
SOURCE: World Bank (2012)

Figure 1-39: External debt stocks in UMICs, 2010



SOURCE: World Bank (2012)

Figure 1-40: Current account balances in UMICs, 2010



SOURCE: World Bank (2012)

average share of GDP. China (47%), Thailand (45%) and Malaysia (44%) are industrial powerhouses, while services tend to be approximately 80% of GDP in most of the SIDS. Countries with a preponderance of industry – especially heavy industry – tend to be more energy and oil intensive and thus more vulnerable to oil shocks than economies which are largely services oriented. Within the UMIC sample, there is a weak negative correlation (-0.33) between the share of agriculture and GNI per capita, which is further illustrated in Figure 1-38.

External debt as a percentage of GNI is on average 56% among the UMICs, while the median level is 46%. Bulgaria, Jamaica, Latvia and Seychelles each had external debt ratios of over 100% in 2011, and are thus greatly exposed to balance of payments shocks, including oil price spikes (Figure 1-39). China (9%), Mauritius (11%) and South Africa (13%) have very low levels of external debt compared to international norms. Interest payments on external debt, which represents a constraint on a country's adaptability to shocks, range from a high of 6.4% of GNI in Jamaica to a low of 0.2% in Mauritius, while the average is 1.7%. Foreign exchange reserves, which provide a buffer against balance of payments shocks in the short run, are on average 92% of external debt in the UMIC sample. However, the median is much lower at 41%, since some countries have amassed enormous reserves – notably China (531%) and Botswana (461%). Three countries (Jamaica, Latvia and Seychelles) have reserves to cover less than a fifth of their external debt.

Nine of the 37 UMICs had current account surpluses in 2010, while the average current account balance was a deficit of 6.5% (Figure 1-40). The largest deficits were recorded for the most part in the SIDS, e.g. St Vincent and the Grenadines (-31%), Grenada (-28%), Seychelles (-23%) and Maldives (-22%). These economies are largely service oriented, and rely heavily on imports of energy and manufactured goods, which is a key vulnerability in the face of rising oil prices as long-distance transport costs will rise.

The large current account deficits in the SIDS are further underscored by the high ratios of trade to GDP in these countries. However the large extent of trade is a common feature of most UMICs, with an average trade/GDP

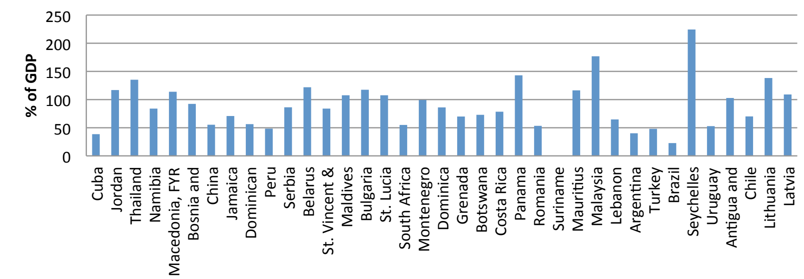
proportion of 91% (Figure 1-41). Brazil (23%), Turkey (48%) and South Africa (55%) are less dependent on trade flows, which means that they are better placed to weather the impacts of oil shocks on shipping costs and export flows.

Socioeconomic statistics

The average Gini coefficient for the sample is 43, which is also the median. The highest Gini figures in the sample are Seychelles (66), Namibia (64) and South Africa (63), while the lowest are the Eastern European nations of Belarus (27), Bulgaria (27) and Serbia (27) (Figure 1-42). These figures indicate a very different income distribution profile amongst the UMICs, with those with higher Gini coefficients are at risk of social conflict in times of economic shocks and social stress. Poverty headcount rates are generally much lower than in less wealthy countries. Out of the 26 UMICs for which poverty data are available, 16 had zero rates of ultra-poverty (i.e., the proportion of the population with income below $1.25 per day), while the average was just 3%. Namibia (32%), South Africa (14%) and China (13%) were the exceptions in this regard. At the $2 per day poverty measure, the average poverty headcount rate was 8%, while the median was just 2%. The highest poverty rates were again in Namibia (51%), South Africa (31%) and China (30%) (Figure 1-42). Only four other countries had poverty rates of 10% or greater.

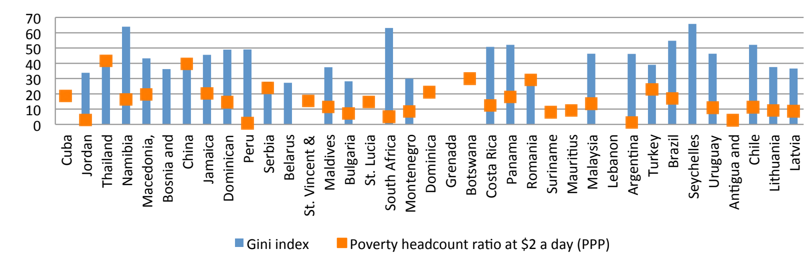
Undernourishment afflicts more than 10% of the population in 11 of the 37 UMICs, most notably in Botswana (25%) and the Dominican Republic (24%), but is just 9% on average (Figure 1-43). Those countries with higher undernourishment rates will have to guard against the inflationary impact of oil price shocks on food prices. Extreme poverty is only moderately correlated (coefficient = 0.45) with undernourishment in this sample. The unemployment rate in this group averages 13%, with a median of 10%. The highest jobless rates in 2010 were recorded in the nations that previously formed part of Yugoslavia – namely Macedonia (32%), Montenegro (30%), Bosnia and Herzegovina (27%), and Serbia (19%) – together with Namibia (38%) and South Africa (24%). These countries are struggling with persistent structural unemployment and in the case of the latter two, serious skills deficits. Overall, it is clear that South Africa and Namibia are amongst the UMICs with the most

Figure 1-41: Trade as a percentage of GDP in UMICs



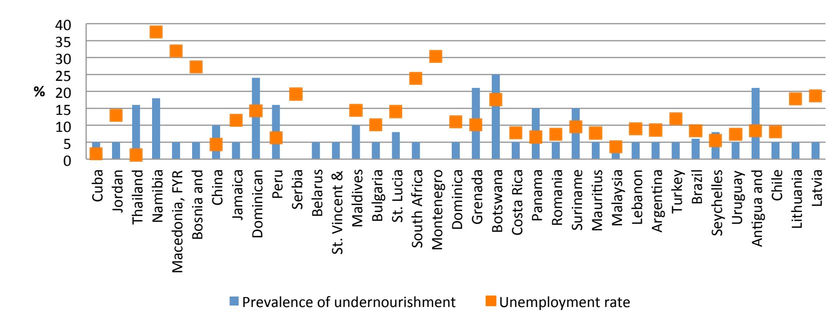
SOURCE: World Bank (2012)

Figure 1-42: Gini index of income inequality and poverty headcount ratio in UMICs



SOURCE: World Bank (2012)

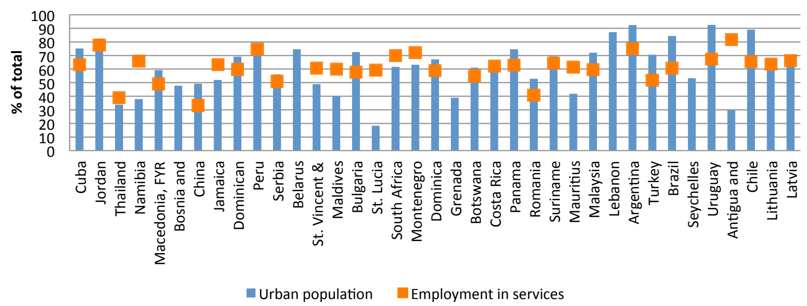
Figure 1-43: Prevalence of undernourishment and unemployment in UMICs



SOURCE: World Bank (2012)

serious socioeconomic problems of poverty, inequality and unemployment, and are therefore particularly at risk of social turmoil as a result of oil-related economic shocks.

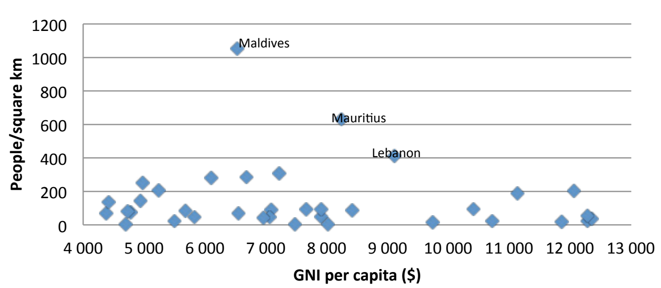
Figure 1-44: Urbanisation rate and percentage of workforce in services in UMICs



SOURCE: World Bank (2012)

The two population giants in this group are China (1,344 million people) and Brazil (197 million), although there are several other nations with populations greater than 25 million (Argentina, Malaysia, Peru, South Africa, Thailand and Turkey). The group also includes nine countries with populations smaller than one million, all of which are SIDS with the exception of Montenegro. Population density (people per square kilometre) varies greatly, from lows of 3 in Namibia and Suriname and 4 in Botswana, to highs of 1,053 in Maldives and 631 in Mauritius. The SIDS tend to have higher population densities than larger countries. As mentioned before, this is a double-edged sword, as although transport costs can be contained in dense settlements, resource-related social and land pressures may become problematic, especially if food imports become expensive or scarce. The average population density for the UMIC group is 146, but the median is considerably lower at 83 people per square kilometre. Most of the UMICs have experienced a substantial migration of people to urban areas over the course of their development, such that the average percentage of the population residing in urban areas is 62% (and the median is 64%) (Figure 1-44). The South American countries of Argentina (92%), Uruguay (92%) and Chile (89%) are somewhat exceptional for this group. On the other extreme, St Lucia (18%), Antigua and Barbuda (30%), Thailand (34%) and Namibia (38%) are still in the early stages of the rural/urban transition.

Figure 1-45: Gross national income per capita and population density in UMICs



SOURCE: World Bank (2012)

Figure 1-45 below shows that there is no discernible relationship between income per head and population density amongst the UMICs. The percentage of the workforce engaged in agriculture is also highly variable, from lows of 5% or less in South Africa, Argentina, Peru, and Jordan, to highs in Thailand (42%), China (40%) and Botswana (30%). There is a weak inverse relationship (correlation coefficient equal to -0.34) between income per capita and agriculture's share of employment. Average employment in agriculture is 15% of total employment, industry accounts for 23% of the workforce, and services, 62%.

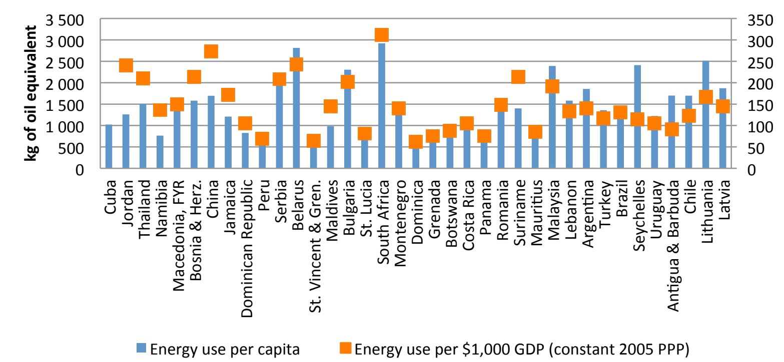
1.4.2 Oil dependencies and vulnerabilities

We turn now to focus on specific measures of energy and oil dependence and vulnerability, including energy indicators, oil production and consumption, measures of oil vulnerability, and transport sector oil dependence.

Energy indicators

Energy consumption per capita averaged 1,453 kg of oil equivalent in 2009, but this masked a high degree of variation, from under 1,000 in seven SIDS plus Peru, Panama and Namibia, to over 2,500 in South Africa, Belarus and Lithuania (Figure 1-46). Energy use per $1,000 of GDP was similarly variable, and was correlated reasonably strongly (0.68) with the per capita measure. South Africa was the most energy intensive UMIC according to both measures.

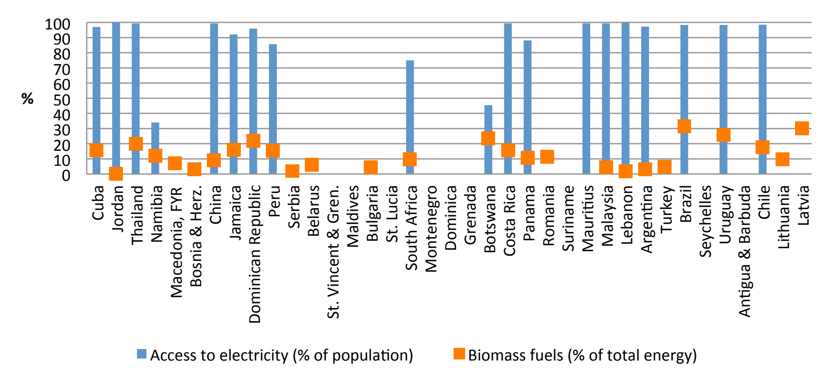
Figure 1-46: Energy intensity in UMICs



SOURCE: World Bank (2012)

Availability of modern energy services is a key difference between middle income and low income countries. Electricity access reached over 90% of the population in 16 of the 19 UMICs for which data were available in 2009 (Figure 1-47). The exceptions were the neighbouring states of South Africa (75%), Botswana (45%) and Namibia (34%), countries characterised by high levels of income inequality and poverty. In contrast, the contribution of traditional biomass fuels (combustible renewables and waste) to total energy was under 10% in 11 of the countries, but comparatively high in countries such as Brazil (32%), Latvia (30%) and Uruguay (26%); the average was 12% in 2009.

Figure 1-47: Access to electricity and use of biomass fuels in UMICs

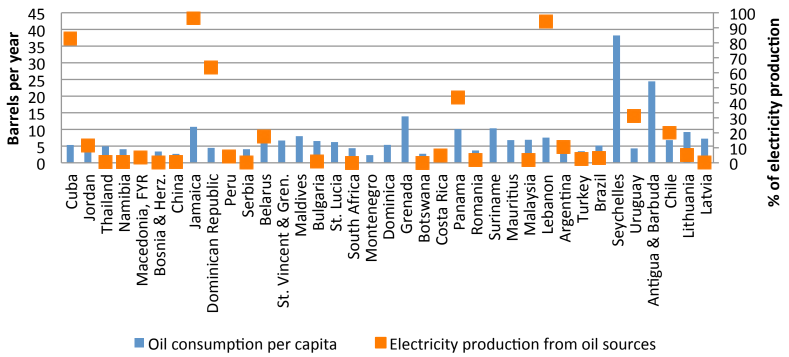


SOURCE: World Bank (2012)

Oil consumption and production

The larger economies mentioned in the previous section are all significant oil consumers, although China is in a league of its own, consuming an average of 9.85 million bpd in 2011 (EIA, 2012). With the exception of Turkey, the largest oil consumers were also the largest oil producers. Twenty-three of the 37 UMICs produced negligible quantities of oil. Crude oil refining capacity is highly correlated (with a coefficient equal to 0.94) with oil production, and so the majority of UMICs are dependent on imports of refined fuels. Oil consumption per capita varies considerably, from lows of under three barrels per year in China, Botswana, Montenegro and Peru, to highs of 38 barrels per year in Seychelles and 24 barrels per year in Antigua & Barbuda. With the two outliers excluded, there

Figure 1-48: Oil consumption per capita and electricity production from oil in UMICs



SOURCE: Own calculations based on EIA (2012) and World Bank (2012)

is no significant correlation between per capita income and oil consumption among the UMIC sample. Out of the 27 countries for which data were available, 17 depended on oil feedstock for less than or equal to 5% of their electricity generation (Figure 1-48). The countries most exposed to power supply disruptions resulting from oil shocks were Lebanon (94%) and three SIDS, namely Jamaica (96%), Cuba (83%) and Dominican Republic (64%). The average dependency on energy imports (as a percentage of total energy consumption) was 45% in 2009, headed by Lebanon (97%), Jordan (96%), Belarus (85%) and Jamaica (84%). Malaysia, South Africa and Argentina were the only UMICs that were net energy exporters in 2009. Thus when oil prices rise, most net oil importing countries lack the ability to offset higher oil import expenditures with revenues from alternative energy exports.

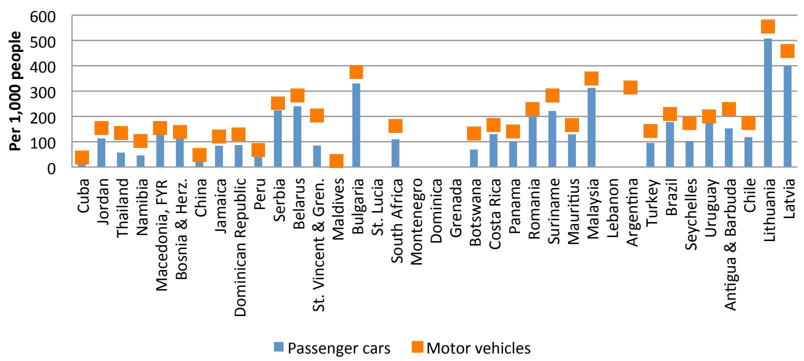
Measures of oil vulnerability for 2011 and 2008 are presented in Table1-3 below. The primary measure of oil vulnerability, namely expenditure on oil expressed as a percentage of GDP, averaged 8% in 2011 (and the median was 7%) when the Brent crude oil price averaged $111 per barrel. Six countries were practically self-sufficient in oil in 2011, viz. Argentina, Brazil, Cuba, Malaysia, Peru and Suriname). Oil vulnerability was extremely high in many of the SIDS, including Seychelles (36%), Antigua and Barbuda (22%), Jamaica (22%), Grenada (20%) and Maldives (14%). With the exception of Belarus, Jordan and Panama, other non-SIDS spent less than 10% of GDP on oil in 2011. Oil vulnerability rose by one percentage point on average between 2008 and 2011, as the average oil price rose by $14/barrel. Oil import dependence (i.e., the share of oil imports in total oil consumption), averaged 79% in 2011, up marginally from the 77% recorded in 2008. Twenty of the 37 UMICs were completely dependent on oil imports. South Africa is an unusual case in that it met 30% of its own petroleum needs, not from crude oil but from synthetic fuels manufactured from coal and gas. Oil intensity (oil consumption as a percentage of total energy consumption) was on average 59% in 2008, but there was a high degree of variability. Oil intensity was extremely high (over 80%) in 13 countries, most of which were SIDS (with the exception of Lebanon and Panama). South Africa and China, both heavy users of coal, had the lowest oil intensity at 19% each.

Table 1-3: Oil vulnerability indicators for UMICs

INDICATOR	OIL VULNERABILITY		OIL IMPORT DEPENDENCE		OIL INTENSITY
UNITS	%		%		%
YEAR	2011	2008	2011	2008	2008
Antigua and Barbuda	22	12	100	100	100
Argentina	-1	-2	-9	-27	37
Belarus	12	7	84	77	30
Bosnia and Herzegovina	8	5	100	100	19
Botswana	3	4	100	100	49
Brazil	0	0	4	-2	47
Bulgaria	10	7	98	97	26
Chile	5	6	95	96	56
China	3	3	56	50	19
Costa Rica	5	6	100	100	53
Cuba	0	5	66	63	86
Dominica	8	7	100	100	90
Dominican Republic	9	10	100	100	82
Grenada	20	8	100	100	100
Jamaica	22	21	100	100	98
Jordan	16	16	100	100	64
Latvia	6	4	100	100	45
Lebanon	8	10	100	100	94
Lithuania	7	5	93	90	37
Macedonia, FYR	8	7	100	100	33
Malaysia	-1	-3	-13	-36	41
Maldives	14	12	100	100	100
Mauritius	9	8	100	100	72
Montenegro	4	3	100	100	22
Namibia	9	8	100	100	57
Panama	13	14	100	100	83
Peru	0.2	2	4	35	52
Romania	3	2	52	47	27
Serbia	6	5	82	81	22
Seychelles	36	26	100	100	100
South Africa	4	4	70	63	19
St. Lucia	10	9	100	100	100
St. Vincent & Grenadines	12	8	100	100	93
Suriname	0	-3	-3	-19	76
Thailand	6	7	58	58	48
Turkey	3	3	92	93	32
Uruguay	3	7	98	98	72
Average	**8**	**7**	**79**	**77**	**59**
Median	**7**	**7**	**100**	**100**	**53**
Std. Deviation	**8**	**6**	**36**	**39**	**29**

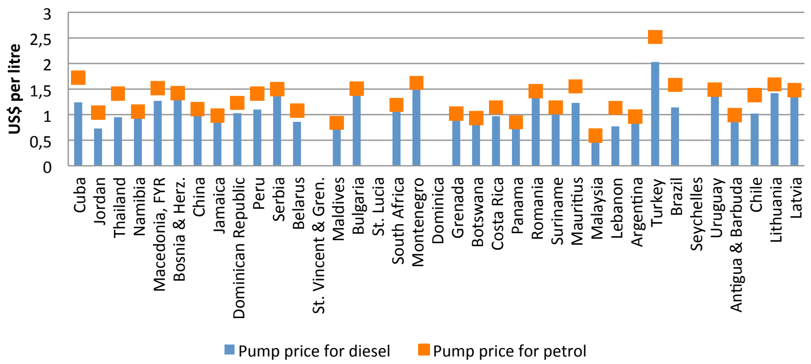
SOURCE: Own calculations based on EIA (2012) and World Bank (2012)

Figure 1-49: Motor vehicle prevalence in UMICs, 2009



SOURCE: World Bank (2012)

Figure 1-50: Petrol and diesel prices in UMICs, 2010



SOURCE: World Bank (2012)

Road transport indicators

The average numbers of motor vehicles (192) and passenger cars (149) per 1,000 people in UMICs are an order of magnitude greater than the corresponding numbers for LICs (Figure 1-49). Lithuania (555) and Latvia (459) top the list when it comes to motor vehicle penetration. Vehicle prevalence is low in Cuba (38) and China (47), although this is changing rapidly in the latter country as household incomes rise. Road sector energy consumption in the UMICs accounted on average for 18% of total energy consumption in 2009. Namibia (37%) and Botswana (31%) topped the scale, owing to their large geographic size and very low population densities, which make them very dependent on road transport. Road sector energy consumption per capita is generally higher in the more wealthy countries.

Average fuel prices for 2010 in the UMICs are shown in Figure 1-50. The average pump price for diesel in 2010 was $1.16 per litre, but was highly variable. Diesel prices were lowest in Malaysia ($0.56/litre), which until recently was a net oil exporter, together with Lebanon ($0.77) and Jordan ($0.73), which benefited from their proximity to the Middle Eastern oil exporters. Diesel was most expensive in Eastern Europe, with Turkey recording the highest price of $2.03/litre, partly due to high fuel taxes. The average pump price of petrol (gasoline) was somewhat higher at $1.31/litre, but prices largely followed a similar pattern to diesel prices across countries. Varying fuel subsidies and taxes explain part of the variation in fuel prices across countries.

1.4.3 Likely impacts of oil shocks

The possible impacts of oil shocks on UMICs overlap to a large extent with those discussed in relation to LMICs in section 1.3.3. In this section, we highlight empirical findings on oil shock impacts by IMF researchers and consider the systemic ramifications of oil supply disruptions. Special consideration is also given to landlocked countries and small island states.

Oil price shocks

In section 1.2.3, we discussed some research that indicated a relatively mild impact of demand-driven oil price shocks on developing countries. However, recent empirical simulation results from the IMF's dynamic general equilibrium model of the world economy demonstrate that supply-driven oil shocks can have very large impacts on world oil prices and output in oil importing countries (Kumhof & Muir, 2012). In the "baseline scenario," which assumes that oil supply growth is constrained to 1 percentage point below its 1.8% average attained between 1981-2005, and that there is a high degree of substitutability of other energy sources for oil, the oil price rises by a cumulative 200% after 20 years, and real GDP in the "rest of the world" (i.e. countries excluding oil exporters, the US and the Euro area) declines by 8% over a similar period. However, after relaxing several of the model's strong assumptions, such as limiting the substitution possibilities for oil by alternative energy sources and by recognising the greater significance of oil to production than its cost share of GDP indicates, Kumhof and Muir (2012) find significantly larger effects on oil prices and GDP. Similarly, in a "larger shock" scenario, which posits a 2% annual decline in world oil supply and a 4% per annum increase in oil extraction costs, the oil price spikes by 200% initially and climbs by a cumulative 800% after 20 years, by which time rest-of-world GDP contracts by about 30%. Combining the technology constraint assumption with the larger shock assumption, results in simulations that indicate potentially devastating economic impacts on developing world GDP. The authors note further that their model assumes a smooth reallocation of resources among industries and of financial resources between oil exporters and oil importers following an oil shock, but suggest that these assumptions may not hold in the real world, in which case the adjustment costs could be considerably higher. The model is also not able to capture non-linear effects of oil supply constraints such as tipping points and self-reinforcing feedback loops.

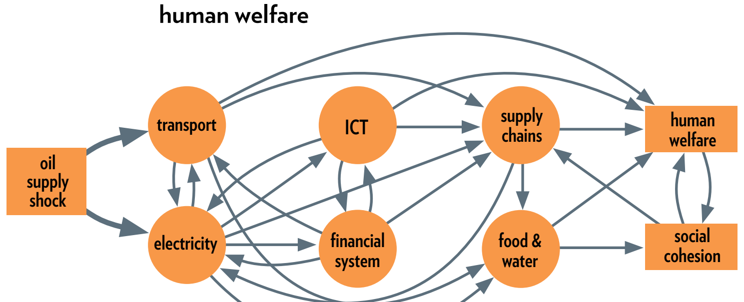
While the above results pertain to the developing world in general, the UMIC group of nations has some particular vulnerabilities to international oil price shocks that are less applicable in the case of poorer countries. First, most UMICs have relatively large stocks of physical capital that are very dependent on oil. This includes transport infrastructure such as cars, trucks, ships and airplanes, but also petrochemical industries such as oil refining and manufacturing of downstream products like plastics, synthetic fabrics and pharmaceuticals. Second, UMICs are in general more closely integrated into the global financial system than are their LMIC and especially LIC counterparts. While this brings benefits in terms of access to foreign sources of financial capital, it also confers a greater risk of financial contagion spreading from other countries. The Asian financial crisis of 1997 was a prime example of how rapidly financial distress in one emerging market can spill over to its peers. Similarly, the Global Financial Crisis of 2008 demonstrated the vulnerability of the entire world financial system to sudden, severe shocks, which in that case affected the global system of commercial trade as well. Third, the agricultural sectors in many UMICs are much more industrialised – and therefore oil based – than those in poorer developing countries. As shown in section 1.3.1, the share of employment in agriculture tends to be low in UMICs, which indicates the relatively capital-intensive nature of farming in these countries. Farming machinery (including some irrigation pumps) is chiefly powered by diesel fuel, while pesticides are manufactured from oil and fertilisers from natural gas. Beyond the production stage, oil is also consumed for the transport, processing and distribution of agricultural commodities and food products. The entire food production and distribution chain thus depends on oil, and the total distance that food is transported from farms to dinner plates is larger in more urbanised societies. Fourth, highly oil-intensive sectors such as construction and tourism are important in many UMICs. Property values in residential, commercial and hospitality markets could be undermined by rising oil and transport costs, raising the threat of bursting property bubbles and associated banking crises.

Although people in UMICs will in general have more resources to cope with the socioeconomic impacts of oil price shocks than those in poorer countries, they will also be adversely affected. Most UMICs have substantial numbers of citizens living in new urban areas, where mobility often depends greatly on private motor vehicles since many cities have expanded in sprawling fashion on the basis of historically cheap petroleum fuels. Citizens who commute to work from outlying suburbs could face a major budgetary shock from higher fuel prices, and are likely to find their mobility constrained. Oil price shocks threaten to tip some households back into poverty, and may well increase rates of income inequality. Rising food prices will also affect citizens of UMICs, and could lead to social instability, as occurred in countries like Mexico in 2008 when corn prices doubled.

Oil supply shocks

As discussed in earlier sections, the impacts of physical oil supply shocks can in some instances be more severe than price shocks. While many of the potential socioeconomic impacts of fuel supply disruptions mentioned for LICs and LMICs would also hold for UMICs, we consider here the systemic ramifications in more technologically advanced societies. National-scale socioeconomic systems are comprised of interconnected subsystems such as energy, transport, communication, financial, water, sewage and food systems, each relying on interdependent critical infrastructures. The socioeconomic system as a whole is therefore an example of a complex system. Changes in certain drivers (e.g. the availability of liquid fuels) might set off self-reinforcing feedback loops and push other variables past thresholds or tipping points such that the system changes in a non-linear fashion. Figure 1-51 represents schematically the linkages between six of the major critical systems operating in the typical upper middle income economy, as well as their connections to human welfare and social cohesion. Oil supply shocks will most directly affect the transport and electricity systems, but from there the impact will be transmitted to other critical systems, as described below:

Figure 1-51: Impact of an oil supply shock on critical systems and human welfare



SOURCE: Adapted from Wakeford (2012, Figure 4-19, page 190)

NOTES: *arrow = causative impact/transmission of oil shock; ICT = information and communication technology.*

- Dislocations of the transport system brought about by fuel shortages can affect electricity generation (e.g. by reducing deliveries of oil or coal to thermal power stations), disrupt product supply chains (i.e. the distribution of raw materials and intermediate and final goods), interrupt food production, processing and distribution, and negatively affect human welfare by constraining mobility (e.g. for accessing workplaces, schools and shops).
- Oil shortages will reduce power generation in countries that use oil to produce electricity, and brownouts or blackouts would negatively affect electric-based transport (e.g. trains and trams) and traffic management, information and communication technology (ICT) systems, product supply chains (e.g. factory production), food storage (e.g. refrigeration) and water distribution (which relies on electric pumps).
- Disruptions to ICT systems would have knock-on effects on supply chains, negative feedbacks to electricity generation, and paralyse the financial system.
- Financial system failure would soon cripple all other critical systems, which rely on smooth processing of economic transactions through monetary exchanges.
- Economic supply chains are critical to the food system and in the medium to longer term are vital to the continued functioning of the electricity and transport systems.

These critical systems are all vital to the maintenance of human welfare, while the major determinants of social cohesion are human welfare in general and access to food and water in particular. The preservation of social cohesion in turn feeds back to human welfare and the effective functioning of supply chains. It is clear therefore that a major crisis in any one of the interlinked subsystems will be transmitted to other subsystems until it reverberates through the entire socio-economy. In a worst case scenario, an electrical grid failure or a systemic banking freeze extending for just a few days could result in widespread hunger, rioting and social disintegration (see Simms, 2008).

Special country categories

Four out of the 37 UMICs in our sample are **landlocked countries**, namely: Belarus, Botswana, Macedonia, and Serbia. While Belarus is well positioned to import oil from Russia by pipeline, the other three countries are somewhat vulnerable to disruptions of the fuel supply chain. Botswana relies entirely on refined fuel imports via South Africa, while the other three countries have excess refining capacity relative to domestic needs. In 2011 oil

import dependence was 100% in Botswana and Macedonia, and over 80% in Belarus and Serbia. Average fuel prices in Macedonia and Serbia were well above the UMIC average in 2010, while prices were subsidised in Botswana and Belarus. In general, with the possible exception of Belarus, these countries are somewhat more susceptible to oil supply shocks than their coastal peers, although a compensating factor is that they each have a very low reliance on oil for electricity generation.

There are twelve **Small Island Developing States** amongst our sample of 37 UMICs, namely: Antigua and Barbuda, Cuba, Dominica, Dominican Republic, Grenada, Jamaica, Maldives, Mauritius, Seychelles, St Lucia, St Vincent and the Grenadines, and Suriname. A further five SIDS that fall within the World Bank's UMIC category were excluded from the sample owing to a lack of data (viz. American Samoa, Mayotte, Palau, Saint Kitts and Nevis, and Tuvalu). Cuba and Suriname are the only members of this group that produce oil; the others are 100% dependent on crude oil imports. Cuba, Dominican Republic, Jamaica and Suriname have oil refining capacity, although this meets less than half of consumption in the latter three countries. Somewhat surprisingly, the average fuel price amongst the SIDS ($1.12/litre) was lower than the average for other UMICs ($1.24/litre) in 2010 (although four missing observations for SIDS might have skewed the average). Although the data are sparse, it seems that many of the SIDS rely heavily on oil for electricity generation, not having an abundance of alternative energy sources. With the partial exception of larger countries like Cuba and Dominican Republic, many of these small states share the kinds of vulnerabilities described for the LMICs, such as lack of economies of scale, undiversified economies, high reliance on fuel-intensive tourism, etc.

1.4.4 Summary

In term of their **socioeconomic and demographic characteristics**, upper middle income countries in general share a number of similarities that increase their vulnerability to oil shocks, including:

- a relatively high degree of integration with the world trade in terms of trade and financial flows;
- moderate to large current account deficits and external debt to GDP ratios; and
- a relatively high average urbanisation rate, which is linked with a relatively high prevalence of motor vehicles and road sector share of total energy consumption, compared to poorer countries.

On the other hand, some general characteristics of UMICs could help to reduce the severity of oil shock impacts, namely:

- a relatively large services sector, resulting in moderate rates of energy intensity per capita and per GDP in most countries;
- relatively low rates of poverty, unemployment and undernourishment; and
- relatively low dependence on oil for electricity generation in most UMICs.

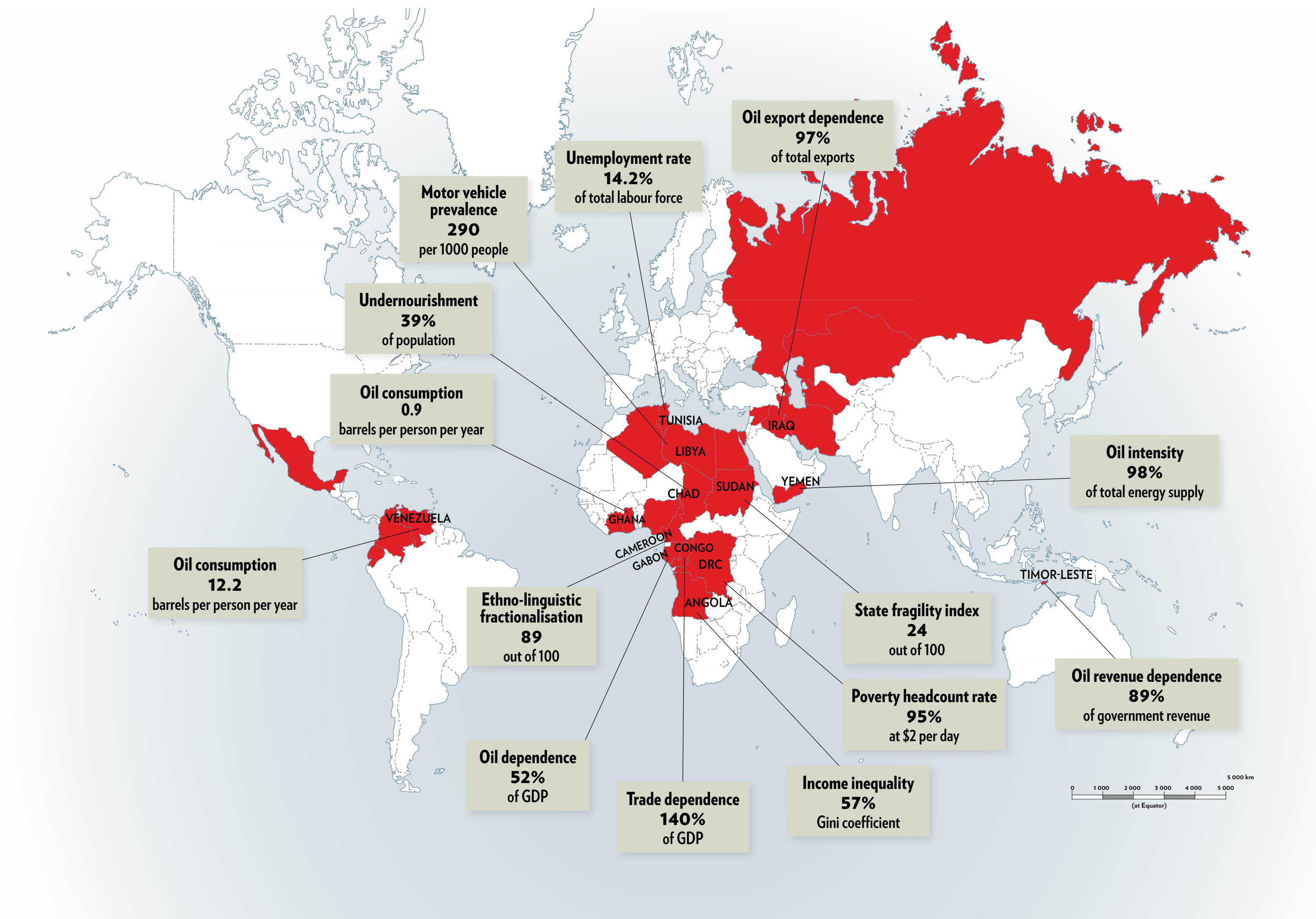
With respect to **oil vulnerability** indicators, in the majority of the UMICs (and on average for the group):

- oil vulnerability is moderately high (an average of 8% of GDP is spent on oil);
- oil resource dependency is very high (averaging 79% of modern fuels in 2011); and
- oil import intensity is high (averaging 59% in 2008).

The major **oil shocks impacts** that can be anticipated for net oil importing UMICs include:

- growing current account deficit and financial account outflows, resulting in exchange rate volatility;
- slowing GDP growth and job losses in vulnerable sectors;
- rising cost of living and constrained mobility for many households;
- in the event of persistent fuel shortages, possible systemic crises in the interconnected transport, electricity generation, financial, communication, food production and distribution, and trading systems.

1.5 Oil Exporting Countries



This section analyses the major oil dependencies and likely vulnerabilities to and impacts of oil price and supply shocks on oil exporting countries (OECs), which include low income countries (LICs), lower middle income countries (LMIC) and upper middle income countries (UMIC). The analysis is based on several public data sources, including the World Bank (2012) Development Indicators, the U.S. Energy Information Administration (EIA, 2012), the International Energy Agency (IEA, 2013b), World Trade Organisation (WTO, 2012) and BP (2012). Our sample includes 27 countries that were net oil exporters in recent years and for which there were a minimum of meaningful data available. Data were not available for all variables for all of the selected countries. A full list of the 27 selected oil exporters is included in the introduction in Table 0-1. The following subsections respectively present the key socioeconomic characteristics of these countries, analyse various indicators of oil dependency and vulnerability, and discuss the probable impacts of oil price and supply shocks.

1.5.1 Key socioeconomic characteristics

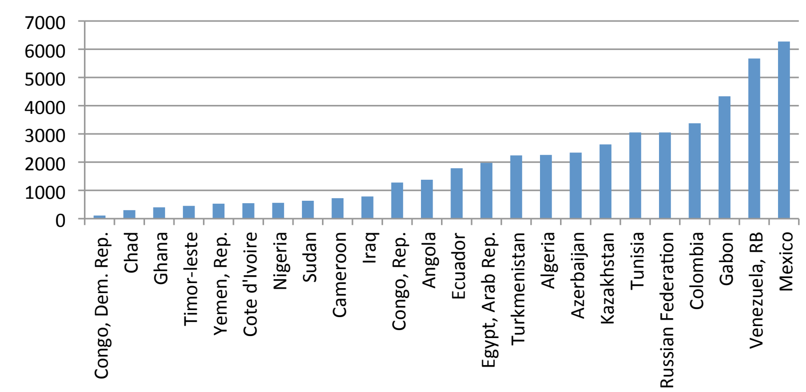
This section presents key data on economic, socioeconomic and demographic characteristics of oil-exporting nations that are relevant to identifying vulnerabilities to oil price volatility. The socioeconomic impacts of oil price rises will be felt by the citizens of OECs to the extent that higher world oil prices are passed through to domestic consumers, in which case many of the impacts would be similar to those described in the preceding sections. In many OECs, however, domestic fuel prices are subsidised so that there is only partial pass-through of world oil prices. The macroeconomic implications of oil price shocks are discussed in sections 1.5.2 and 1.5.3.

Most of the oil exporting countries (14 out of 24) have a **GDP per capita** of more than US$1,000 (Figure 1-52), although many are still below this mark (10/24). Those oil exporting countries with a GDP per capita of less than US$1,000 are mainly the Central and West African nations (DRC, Chad, Ghana, Ivory Coast, Nigeria, Sudan, and Cameroon), Small Island Developing States (Timor-Leste) and two Middle Eastern nations (Yemen and Iraq).

The majority of low and lower middle income countries (LICs and LMICs) exporting oil also have low economic diversification measured as relatively **high primary activity as a percentage of GDP** (Figure 1-53), while upper middle income countries (UMICs) have more diversified economies. The least diversified include the Central and West African countries as well as some Middle Eastern countries of Syria and Egypt.

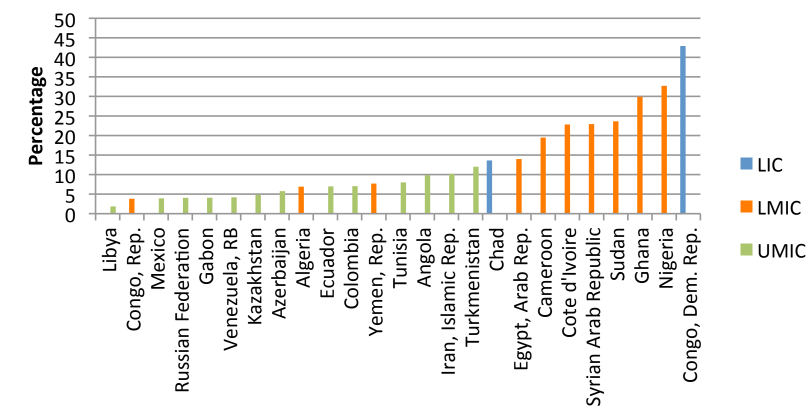
There is no discernible relationship between **trade openness** and development status at low levels of trade openness (Figure 1-54). However, the UMIC oil exporters do exhibit more trade openness, which exposes them to possible "Dutch disease" impacts of rising real exchange rates following oil price spikes (as discussed in more detail below).

Figure 1-52: GDP per capita in OECs, 2011 (constant 2000 US$)



SOURCE: World Bank (2012)

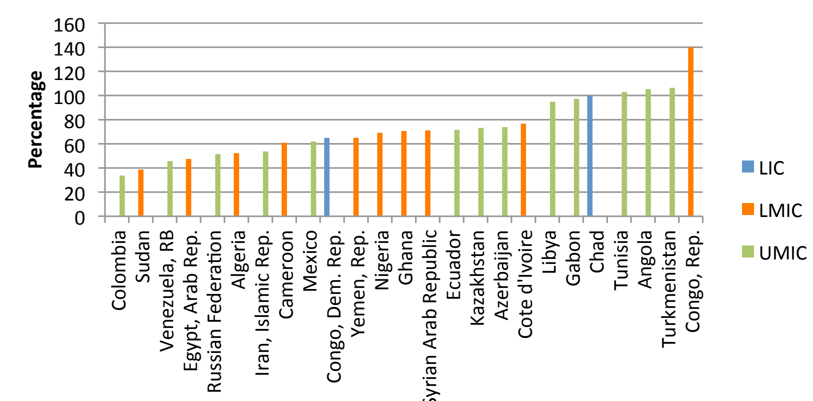
Figure 1-53: Primary activity as percentage of GDP in OECs, 2010 or latest



SOURCE: World Bank (2012)

NOTES: *LIC = low income countries; LMIC = lower middle income countries; UMIC = upper middle income countries*

Figure 1-54: Trade openness as percentage of GDP in OECs, 2010 or latest

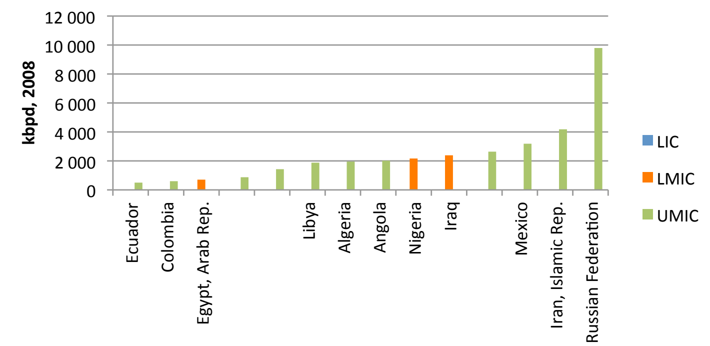


SOURCE: World Bank (2012)

NOTES: *LIC = low income countries; LMIC = lower middle income countries; UMIC = upper middle income countries*

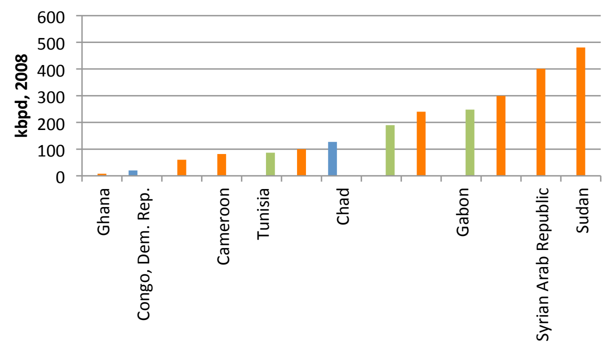
Figure 1-55: Top 14 oil producers amongst OECs, 2008

High production equals wealth but low production does not necessarily imply poverty.



SOURCE: World Bank (2012)

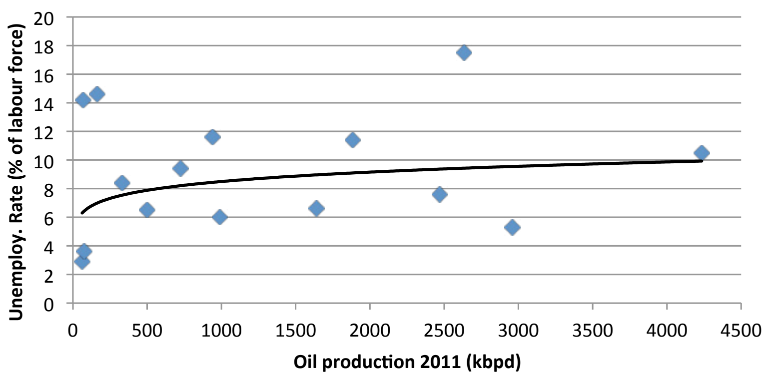
Figure 1-56: Bottom 13 oil producers amongst OECs, 2008



SOURCE: EIA (2012)

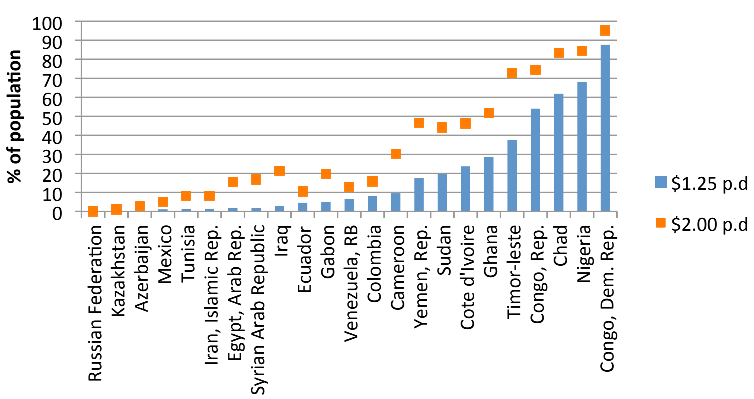
NOTES: *LIC = low income countries; LMIC = lower middle income countries; UMIC = upper middle income countries*

Figure 1-57: Relationship between the unemployment rate and oil production in OECs



SOURCE: World Bank (2012); EIA (2012)

Figure 1-58: Poverty headcount ratio at different income threshol-ds in OECs, 2010 or latest



SOURCE: World Bank (2012)

In general, high **oil production** among oil exporting nations is associated well with higher levels of development (Figure 1-55). Only three of the highest oil producers are not upper middle income countries, namely Nigeria, Iraq and Egypt.

Low oil production does not necessarily lead to lower socioeconomic status, but only three of the bottom 13 oil producers are upper middle income countries (Figure 1-56). The rest are either lower middle income or low income countries.

Higher oil production does not lead to higher overall **employment** in oil exporting countries (Figure 1-57). Although the relationship is not very strong, increased oil production may even be associated with a slight increase in the overall unemployment rate, possibly because other industries are not adequately developed.

The **poverty** headcount ratio shows the percentage of the population living on less than $1.25 per day (Figure 1-58). This is also compared with the percentage of the population living on less than $2 per day (red squares in Figure 1-58). The results indicate that while just more than half (14/23) of oil exporting countries have low poverty rates, with less than 10 percent of the population earning less than $1.25 per day, some of these countries have much higher poverty rates at a poverty threshold of $2 per day. Egypt, Syria, Iraq and Gabon all have a poverty rate of around 20% of the population if this broader measure is used. At the other end of the scale, Timor-Leste (SIDS) and the Central and West African economies (with the notable exception of Gabon and to some extent Cameroon) have the highest poverty rates, with more than 50% of the population earning less than $2 per day. Yemen is also vulnerable at the higher poverty threshold of $2 per day. While most of the OECs with high poverty rates are relatively small oil producers, a notable exception is Nigeria, where oil revenues have by and large done little to reduce poverty rates (see also the Nigerian case study).

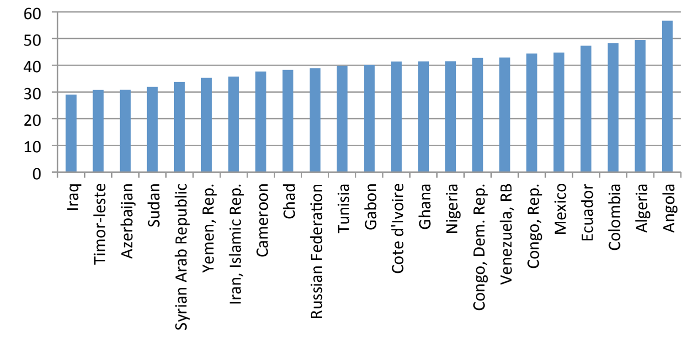
There is not a large spread of **income inequality** amongst oil exporting nations (Figure 1-59), with the Gini Index for most countries falling between 30 and 50. Countries with the highest income inequality are in Africa (Angola, Algeria, Congo, DRC and West Africa) and a number of countries from the Americas (Colombia, Ecuador, Mexico and Venezuela).

There is no specific association between **undernourishment** and oil exporting countries (Figure 1-60). Approximately half the countries have a low prevalence of undernourishment (less than 5 percent of the population undernourished). For those with a high prevalence of undernourishment, again there is no discernible geographical trend. Countries from the Americas, Africa, Small Island Development States (SIDS) and the Middle East are all featured amongst the countries with the highest rates of undernourishment.

The vast majority of oil exporting nations are **urbanised** (Figure 1-61). In 19 out of the 27 countries analysed the urbanisation rate was over 50%. In general, poorer OECs tend to have lower rates of oil consumption and urbanisation.

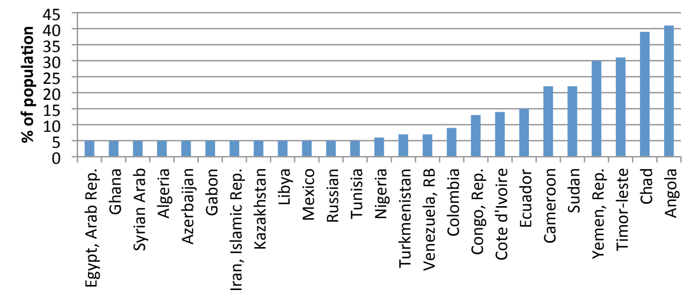
Only four of the oil exporters have large populations and high oil production (Figure 1-62): Nigeria, Mexico, Iran and Russia. These countries rank amongst the world's top ten oil exporters and stand somewhat apart from the other countries in our sample.

Figure 1-59: Gini Index in OECs, 2009 or latest



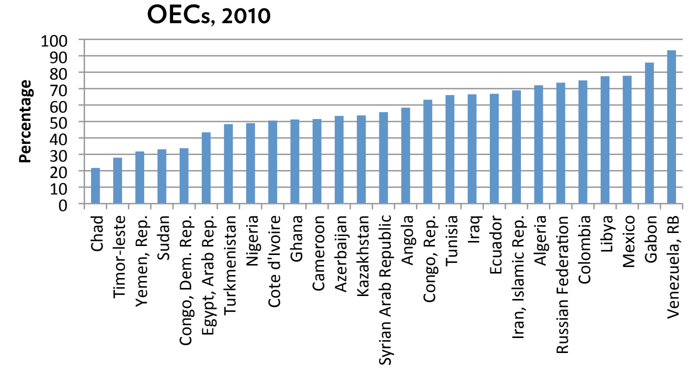
SOURCE: World Bank (2012)

Figure 1-60: Prevalence of undernourishment in OECs, 2008



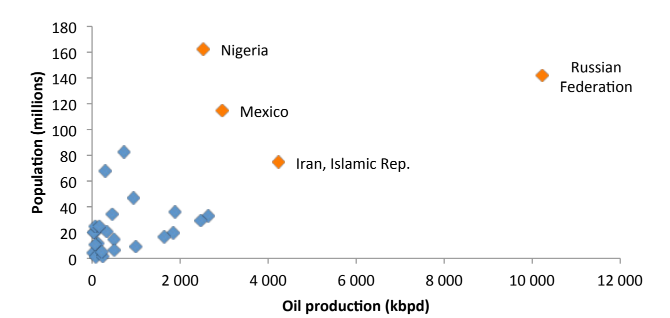
SOURCE: World Bank (2012)

Figure 1-61: Urban population as percentage of total population in OECs, 2010



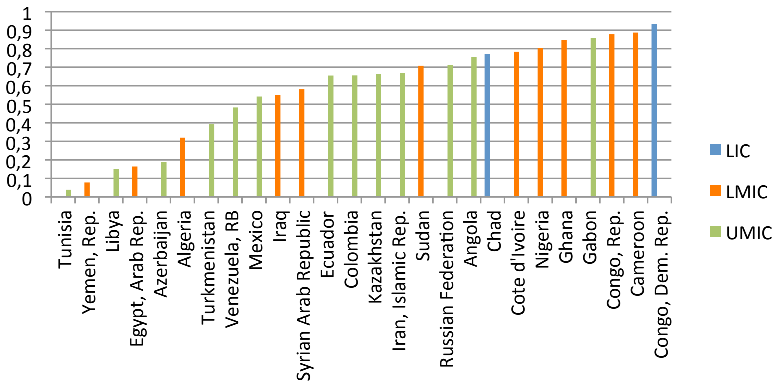
SOURCE: World Bank (2012)

Figure 1-62: Relationship between oil production and population in OECs, 2011



SOURCE: Oil production: EIA (2012); Population: World Bank (2012)

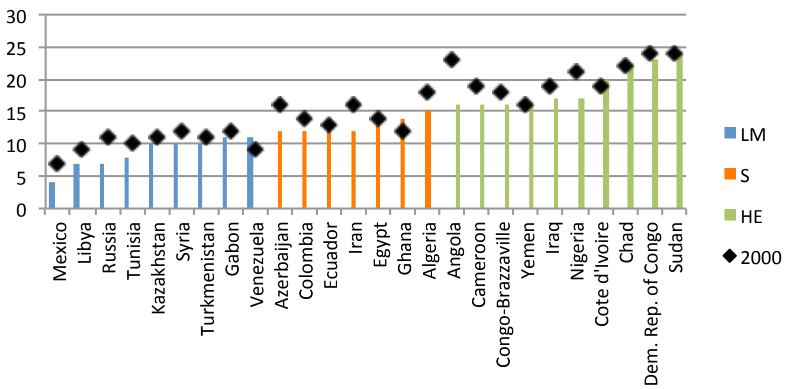
Figure 1-63: Index of ethno-linguistic fractionalization (ELF) in OECs



SOURCE: Fearon (2003)

NOTES: *LIC = low income countries; LMIC = lower middle income countries; UMIC = upper middle income countries*

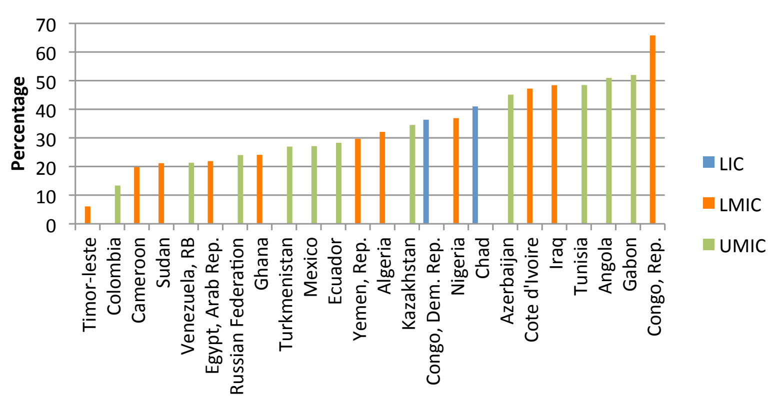
Figure 1-64: State Fragility Index (SFI) for OECs, 2010



SOURCE: Marshall and Cole (2010)

NOTES: *The State Fragility Index (SFI) scores each country on both Effectiveness and Legitimacy in four performance dimensions: Security, Political, Economic, and Social, at the end of the year 2010. Key: LM=Low and moderate, S=Serious, HE= High and Extreme, 2000= SFI for the year 2000.*

Figure 1-65: Oil's share of total exports in OECs, 2010



SOURCE: Oil price: BP (2012); Crude oil exports: EIA (2012). Exports of goods and services: WTO (2012)

NOTES: *LIC = low income countries; LMIC = lower middle income countries; UMIC = upper middle income countries*

Many of the poorest countries are **ethnically diverse**, with seven of the eight most ethnically diverse countries with an Ethno-Linguistic Fractionalization (ELF) score of greater than 0.76 (Fearon, 2003) (Figure 1-63). The only exception is Gabon with an ELF of 0.857. The less ethnically diverse countries are not necessarily the wealthier countries, although certainly not low income countries, but are more often Middle East, North African, Central Asian and South American countries. The more ethnically diverse countries are likely to be at greater risk of civil tensions following oil shocks or oil price volatility.

The State Fragility Index (SFI) measures how **fragile a country** is in terms of security and social, economic and political legitimacy and effectiveness (Marshall and Cole, 2010). In most oil exporting countries, state fragility has improved between 2000 and 2010 (Figure 1-64). Amongst the countries with a low t-o moderate SFI, Venezuela has worsened. Amongst those countries rated serious, Ghana has worsened between 2000 and 2010. Amongst those countries with high and extreme fragility indexes, Cote d' Ivoire has deteriorated while Chad, Sudan and Yemen have remained the same.

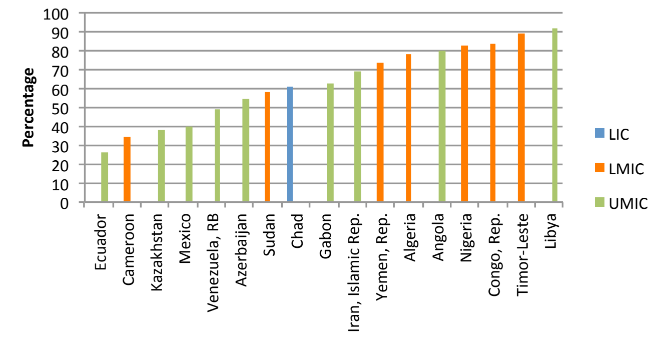
1.5.2 Oil dependencies and vulnerabilities

Oil exporting countries' oil dependencies relate to the extent to which they rely on oil to meet their energy needs and to provide export earnings and government revenues, as well the extent to which oil contributes to overall GDP. Their vulnerabilities to oil supply shocks relate to declines in domestic oil production and/or rapidly rising domestic consumption of oil.

There is no discernible relationship between economic development status and the **share of oil in total exports** (Figure 1-65), but four countries are heavily reliant on oil exports. For Congo, Sudan, Iraq and Angola oil exports comprise more than 80% of the total value of exports. Thirteen of the 27 OECs derive more than half of their export revenues from oil.

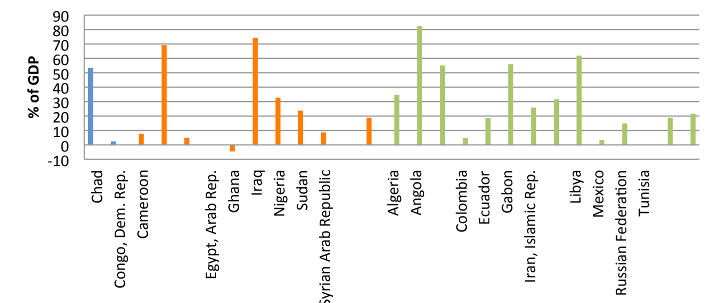
For the majority of countries, governments of oil exporting countries are vulnerable to oil price falls. Ten out of the seventeen countries for which data are available receive

Figure 1-66: Oil revenue's share of total government revenue in OECs, average 2005-8



SOURCE: Villafuerte and Lopez-Murphy (2010)

Figure 1-67: Oil revenue as a percentage of GDP in OECs, 2008



SOURCE: Net oil exports: EIA (2012); GDP: World Bank (2012); Oil price: BP (2012)

NOTES: *LIC = low income countries; LMIC = lower middle income countries; UMIC = upper middle income countries*

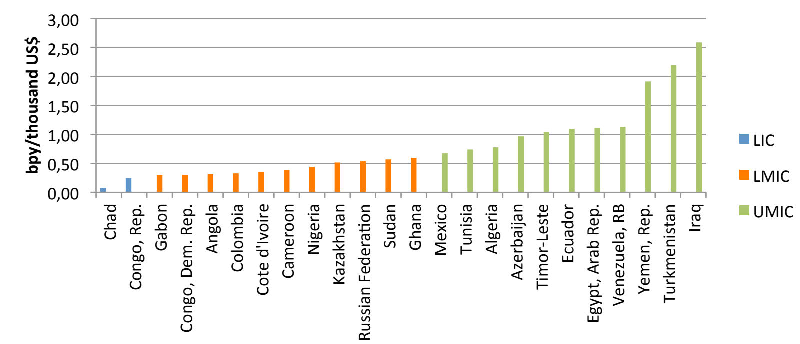
more than 60 percent of their **fiscal revenue from oil** (Figure 1-66). The majority of lower middle income countries (LMICs) fall into this category.

Oil revenue as a percentage of GDP varies greatly among the oil exporting countries, and is not correlated with income status (Figure 1-67). The countries with the greatest degree of economic dependence on oil exports are Angola (82%), Iraq (74%) and Republic of Congo (69%), with seven more countries deriving more than 30% of GDP from oil sales. On the other end of the scale were countries such as Mexico, Colombia, Cameroon, Cote d'Ivoire, Democratic Republic of Congo and Syria, each of which derived less than 10% of GDP from oil revenues. Ghana had not yet begun producing oil in 2008. According to the data, Timor-Leste gained oil revenue five times larger than their GDP in 2008, which appears to be anomalous unless they import goods and services worth a similar value to their oil exports.

The ratio of oil consumption per dollar of GDP measures the contribution of **domestic oil consumption to GDP**. The higher the ratio is, the higher the cost of converting oil consumption into GDP. Figure 1-68 indicates that oil consumption is very well related to development. The more developed the economy, the higher the oil consumption per unit of GDP.

On the whole, **oil consumption per capita** is stratified for income (Figure 1-69). Countries that consume relatively more oil per capita compared with development status include Iraq and Syria, and to a lesser extent Egypt and Yemen.

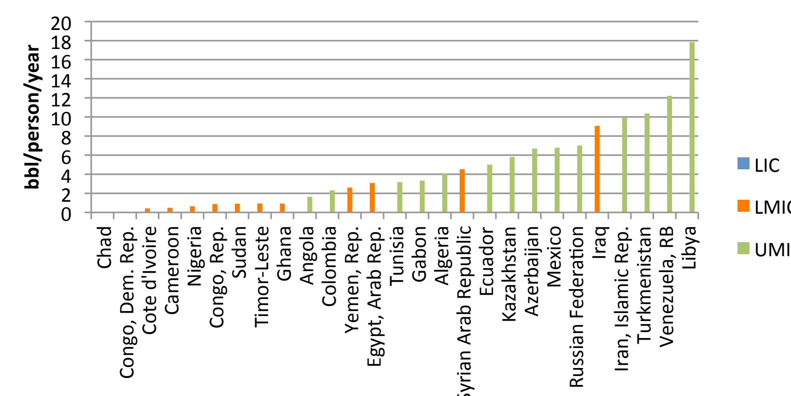
Figure 1-68: Ratio of oil consumption to GDP in OECs, 2011



SOURCE: Oil consumption: EIA (2012). GDP: World Bank (2012)

NOTES: *LIC = low income countries (blue); LMIC = lower middle income countries (red); UMIC = upper middle income countries (green)*

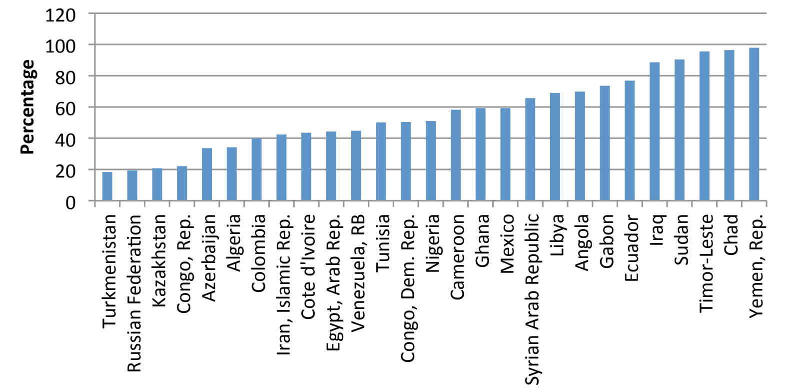
Figure 1-69: Oil consumption per capita in OECs, 2011



SOURCE: Oil consumption: EIA (2012); Population: World Bank (2012)

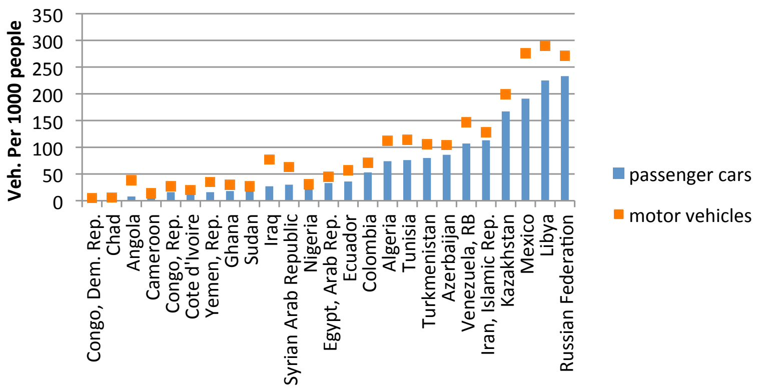
NOTES: *LIC = low income countries; LMIC = lower middle income countries; UMIC = upper middle income countries*

Figure 1-70: Oil intensity of OECs, 2008



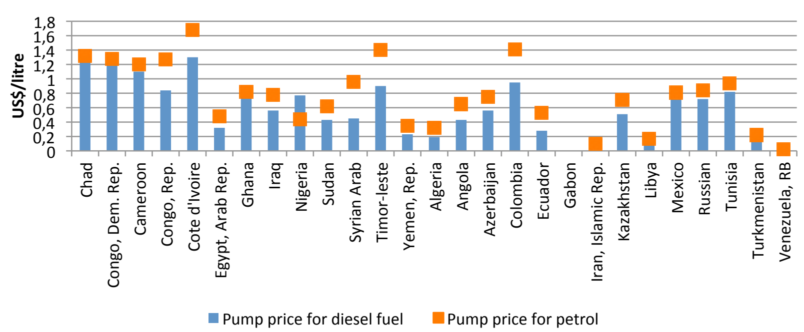
SOURCE: EIA (2012)

Figure 1-71: Vehicles per 1000 people in OECs, 2009 or latest



SOURCE: World Bank (2012)

Figure 1-72: Petrol and diesel prices in OECs, 2010



SOURCE: World Bank (2012)

Oil intensity measures oil consumption's share of total energy consumption (Total Primary Energy Supply, or TPES). A wide range of values is obtained for oil exporting countries, from less than 20% (Turkmenistan) to almost 100% (Yemen) (Figure 1-70). The countries with the highest oil intensity are highly dispersed geographically. Countries (apart from Yemen) with more than 80% oil intensity include Iraq, Sudan, Timor-Leste, and Chad.

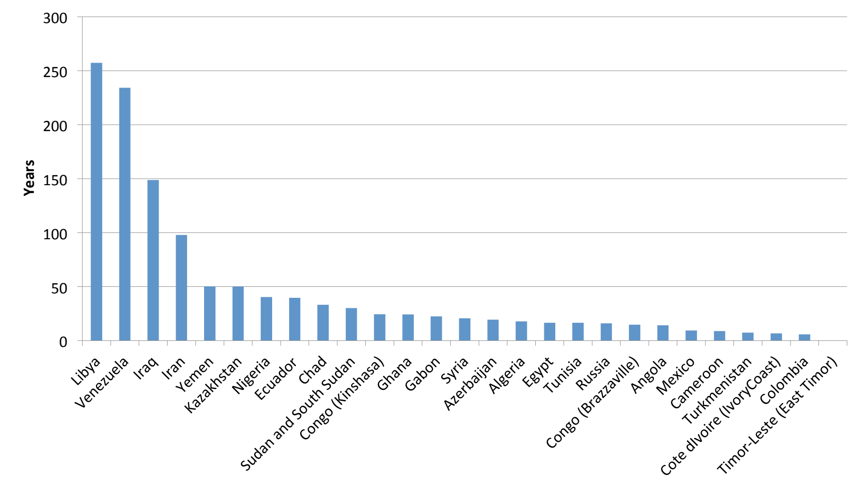
In about half of the oil exporting nations (mostly in poorer African countries), **domestic vehicle use** is extremely low: less than 50 passenger vehicles per 1000 people (compared to around 170 per 1000 worldwide) (Figure 1-71). However vehicle prevalence is comparatively high in a few of the wealthier OECs. In a number of countries (such as Angola, Iraq, Syria, Mexico and Libya) motor vehicle use is significantly higher than the use of passenger cars. This suggests a higher prevalence of buses and freight vehicles in these countries.

A key characteristic of most OECs is that they heavily subsidise the **domestic prices of petroleum fuels**. The average prices of petrol and diesel in OECs in 2010 were $0.61 and $0.77, respectively, compared to average prices of $0.97 and $1.14 in oil importing LMICs. The largest subsidies are evident in Venezuela, Iran and Libya, while the smaller African producers tend to have fuel prices more comparable to the oil importers (Figure 1-72). One of the consequences of large fuel subsidies in some OECs is that per capita rates of domestic fuel consumption are considerably higher than they otherwise would be, hence reducing the volume of oil available for export.

For oil exporting nations, oil supply shocks relate to the flow of domestic oil production rather than the global supply of oil. The majority of oil exporters (23/27) have 50 years or less of proved oil **reserves** remaining at the 2011 **production rate** and 14/27 have less than 20 years left (Figure 1-73). It is only Venezuela, Libya, Iraq and Iran that have reserves left to sustain production for 100 years or longer at current rates. However, reserve-to-production (R/P) ratios can be misleading and are less important than annual flow rates of oil production. For example, a country with declining oil production that is past its peak rate (e.g. Indonesia) can nevertheless have a rising R/P ratio. Several OECs appear from their production histories to be permanently past their peak oil production rates, including Indonesia, Egypt, Iran, Mexico and Russia.

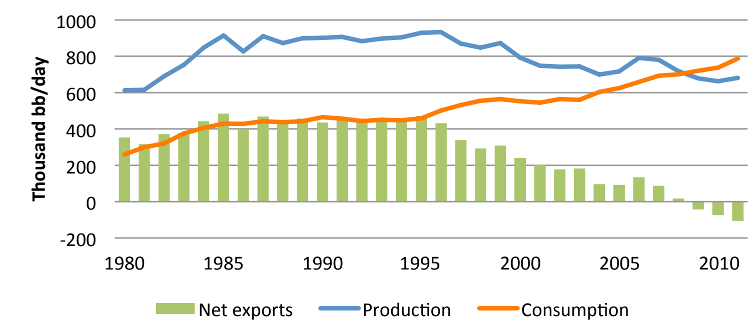
However, many OECs are experiencing rapid growth in domestic oil consumption, driven by population growth and rising national incomes, particularly in recent years as oil revenues have increased dramatically on the back of high world oil prices. Rising domestic oil consumption cuts into the volume of oil available for export. In countries where domestic consumption is rising more rapidly than production, net exports are declining. In some OECs, such as Mexico, the annual rate of production is also in decline, so that net exports are falling very rapidly. This dynamic of falling net exports presents a significant vulnerability for these countries, many of which are reliant on oil export revenues to balance their government budgets and provide sufficient foreign exchange for imports of food and capital goods. Egypt provides a prime example of this dynamic (Figure 1-74). In recent years, rising consumption and falling production of oil has turned several former net oil exporters into net oil importers, such as Indonesia, Uzbekistan, Argentina, Vietnam and Malaysia.

Figure 1-73: Proved reserves to production (R/P) ratios in OECs (years)



SOURCE: EIA (2012)

Figure 1-74: Oil production, consumption and net exports in Egypt, 1980-2011



SOURCE: EIA (2012)

1.5.3 Likely impacts of oil shocks

The likely impacts of oil price shocks on oil exporting countries are complex and oil exporters are not a homogeneous group by any measure. The following observations are made:

- **Exchange rates:** Exchange rates tend to appreciate in energy exporting countries when oil prices rise, adversely affecting the value of non-oil exports and favouring imports (so called 'Dutch disease') (Baumeister et al. 2010).

- **Inflation and interest rates:** In energy importing countries, monetary policy authorities typically raise interest rates to counteract inflationary pressures. For energy exporting economies, this policy response is weaker and much less necessary (Baumeister et al. 2010). Chang et al (2011), however, found that with time, CPI does tend to increase after an oil price shock. This is attributed to the higher price of imports from non-oil exporting nations, which are not shielded from a positive shock in energy prices. Some monetary policy intervention may therefore be necessary over the longer term.

- **Income growth:** Hamilton (1983) found that the oil price shocks of the 1970s had a significant adverse effect on output in the US economy. More recently, studies have found not only changes in the structural nature of impacts over time, but also differences between energy importing and energy exporting countries (e.g. Jiménez-Rodríguez and Sánchez, 2005). Baumeister et al. (2010) found that GDP output increases in countries that export oil and other forms of energy when oil shocks occur, but declines temporarily for countries whose only energy export is oil. The reason for this is found in the correlation between the price of oil and the price of other energy products.

- **Employment:** In some cases an increase in oil prices increases aggregate wealth and demand in oil exporting countries which reduces unemployment (Bjørnland, 2009). However, this effect is dependent on the amount of integration of the oil sector with the domestic economy. In Nigeria, for example, domestic firms have a much smaller stake than multinational firms in their petroleum industry, and generate few employment opportunities for the majority of Nigerians (Harper, 2003). High government revenues from oil (see Figure 1-66) imply a greater potential for government expenditure, which has multiplier effects on employment (even if very inefficient or corrupt in certain countries). For example, in Iraq, Roberts (2004) found that a 10 percent increase in government expenditure would create 117,300 jobs, or a 3% increase in total employment.

- **Resource curse:** Sachs and Warner (1995) provided econometric evidence that countries with greater natural resource wealth grow slower than countries that are poor in resources, spawning a large literature on what has become known as the 'resource curse'. Ross (1999) defines the 'resource curse' as the combination of two influences that follow resource booms: an appreciation of the real exchange rate of an economy caused by a rise in exports (also known as 'Dutch Disease'); and the other that the resources sector draws capital and labour away from manufacturing and agriculture, increasing their production costs, decreasing their exports and inflating the costs associated with the non-tradable sector (the 'crowding out' hypothesis). As Frankel (2012) pointed out, these are not the only two explanations that are given though. Other hypotheses include:
  - the long-term downward trend of commodity prices relative to prices of other goods and services. Empirical evidence however is mixed, depending largely on the time period studied (Frankel, 2012).
  - the volatility of commodity prices, especially for oil and natural gas, negatively impacting on economic growth. It has been pointed out that the degree of integration in the global economy must also be taken into account in response to volatility (Jacks *et al,* 2011).
  - the weak quality of institutions and governance and lack of constraints is associated with authoritarian governments and powerful elites plundering resource-rich countries. As observed by Frankel (2012), empirical evidence for this thesis point specifically to 'point sources', including oil (see Isham 2005; Sala-i-Martin and Subramanian, 2003).
  - a situation characterised by a rapid depletion of resources, anarchy, property rights that are not enforceable and civil war.

It comes therefore as no surprise that evidence for resource curse amongst oil exporting nations is mixed. Sala-i-Martin and Subramanian (2003) found no evidence of the resource curse in Nigeria following oil price shocks. Gelb's (1988) study of seven oil exporters during the 1971-83 oil boom found evidence for resource curse in four of these: Ecuador, Iran, Nigeria and Trinidad and Tobago. More recently, Ismail's (2010) study of fifteen oil exporters did find evidence for the 'crowding out thesis' of the resource curse: a 10% oil windfall is associated with a 3.4% fall in manufacturing value added. According to Ismail (2010), countries that have restrictions on capital flows have a lesser impact as do economies that are more capital intensive. Van der Ploeg (2011) found that if the oil exporting country is small and the oil windfall large, then a country may be able to avoid a resource curse by importing capital and migrant labour. Given these arguments, therefore, there is evidence for a resource curse amongst oil exporters, although this is by no means irrefutable and very dependent on each particular situation, opening up the possibility of managing natural resources as a blessing.

- Transport mobility: Since most of net oil exporter's energy demand is met through domestic production, domestic energy prices are seldom synchronised with international energy prices (e.g. Choucri, 1986 and more recently Mehrara, 2007), and are consequently less affected by international oil price shocks. In general, domestic transport mobility is therefore less affected by oil price shocks compared with non-oil producing nations.

- Poverty and food security: The citizens of oil exporting countries may be vulnerable to the impacts of world oil price shocks to the extent that these prices are passed on directly (in the form of higher domestic petroleum product prices) and indirectly via imported inflation for other goods whose input costs have risen. The effects of oil price shocks on poverty, distribution and food security is discussed in the previous sections and in Cantore et al. (2012). Following these authors, oil price shocks have had adverse effects on food security and poverty in developing countries. Certain population segments, notably, the landless, informal sector workers and female-headed households, are particularly at risk. Household surveys in several countries indicate that poorer households are adversely affected since a higher proportion of monthly expenditure is spent on oil products.

- Civil conflict: A World Bank study by Bannon and Collier (2003) found that the likelihood of violent secessionist movements (movements where a subgroup secedes, or attempts to withdraw from membership of a particular nation or group) is much more likely if the country has valuable natural resources. The likelihood of secessionist conflict is exacerbated by the presence of oil. Without oil the risk that a war is secessionist is 68%. With oil this increases to 100%. Examples of regions where secessionist conflicts have occurred include Aceh (Indonesia), Biafra (Nigeria), Cabinda (Angola), Katanga (ex-Congo), Sudan/South Sudan and West Papua (Indonesia). The finding of a new natural resource or discovery of a greater endowment of a known resource increases the potential for conflict in low-income countries, and more so if the resource that is discovered is oil (Bannon and Collier, 2003). The oil exporter group of countries include four fragile and conflict affected states (FCS), namely Chad, Cote d'Ivoire, Democratic Republic of Congo and Timor-Leste (World Bank, 2012c).

1.5.4 Summary

Oil exporters are a heterogeneous group with various levels of socioeconomic development and different types of vulnerabilities.

In terms of their socioeconomic characteristics the evidence for oil exports improving socioeconomic conditions is mixed. On the one hand, there is some evidence to suggest that oil production is linked to lower poverty levels and greater development. On the other hand, higher oil production has not, by and large, reduced unemployment rates. This may in part be due to reduction in employment in non-oil sectors.

In terms of oil dependencies and vulnerabilities, a number of African countries and small island development states are heavily reliant on oil exports and revenues, including: Congo, Sudan, Angola, Nigeria and Timor-Leste. Other more developed economies are heavily reliant on oil for domestic consumption such Iraq, Iran, Turkmenistan, Yemen, Libya and Venezuela. There is further no discernible geographical trend on countries with high prevalence of undernourishment. In most oil exporting countries, state fragility has improved between 2000 and 2010, with very high state fragility in Sudan, DRC, Chad and Cote d'Ivoire.

In terms of the likely impacts of oil shocks, there is some, but case specific, evidence for the 'resource curse' amongst oil exporting economies, with appreciating exchange rates ('Dutch Disease'), adverse impacts on manufacturing and non-tradables ('crowding out'), weak institutions and governance as well as symptoms of anarchy and even civil war. The discovery of oil increases the risk of and has also led to secessionist violence in a number of countries.

1.6 Summary and Conclusions

This concluding section of Part 1 provides a comparative assessment of the oil shock vulnerabilities and impacts across the different country categories, based on the most pertinent average socioeconomic and oil dependency data drawn from the country samples presented in the foregoing sections. Most of this comparative analysis is based on the oil importing countries (LICs, LMICs and UMICs), since the oil exporter group is in a fundamentally different class of country when it comes to oil shock vulnerabilities and impacts.

The data in Table 1-4 below confirm that the following generalisations hold across the three country categories based on income levels:

- per capita oil consumption rises with income;
- the contribution of agriculture to GDP falls as income rises;
- the contribution of industry to GDP initially rises as countries progress from low income to lower middle income level, but then stabilises as income rises further; and
- the contribution of service sectors to GDP rises as income per head rises.

Since the oil exporter sample includes two low income, twelve lower-middle income, and thirteen upper-middle income countries, it is not surprising that the averages for per capita income and oil consumption fall within the mid-range of the oil importers. The contribution of industry to GDP is particularly high in OECs, as this sector includes oil production and processing.

The socioeconomic indicators (Table 1-5) reveal the following generalisations across the three income categories of oil importers:

- electricity generation from oil as a percentage of total power production is somewhat higher on average in LICs than in the other two categories;
- motor vehicle prevalence (on a per capita basis) increases with income level;
- the proportion of the population living in urban areas increases with income;
- income inequality is on average only marginally (positively) related to per capita income level; and
- the headcount poverty ratio is inversely related to per capita income.

Table 1-4: Summary of economic indicators for the four generic country categories

INDICATOR	GNI PER CAPITA	OIL CONSUMPTION PER CAPITA	AGRICULTURE, VALUE ADDED	INDUSTRY, VALUE ADDED	SERVICES, ETC., VALUE ADDED
UNITS	CURRENT US$	BARRELS/YR	% OF GDP	% OF GDP	% OF GDP
YEAR	2011	2011	2010	2010	2010
LIC average	574	0.5	31	22	47
LMIC average	2 378	2.4	17	29	54
UMIC average	7 693	7.3	7	28	66
OEC average	4 229	4.5	13	44	43
Correlation with GNI per capita (importers only)		0.67	-0.69	0.08	0.59

SOURCE: Own calculations based on EIA (2012) and World Bank (2012)

Interestingly, the average reliance on oil for electricity generation in OECs is less than in LICs. Motor vehicle prevalence is apparently related more to income level than to a country's oil exporter status.

Average oil vulnerability indicators for oil importers are presented in Table 1-6. Interestingly, the average percentage of GDP spent on oil is virtually the same across the three income categories. However, mean oil import dependence falls slightly as income level rises, although this discrepancy diminished between 2008 and 2011. Average oil intensity is higher in LICs (71%) than in the other two categories (59% each). Finally, average energy intensity is much the same in LICs and UMICs, but nearly 50% higher amongst the LMICs. This makes sense, since as countries develop they generally move from specialisation in agriculture, to energy-intensive heavy industries, to higher-technology industries, to services.

Table 1-5: Summary of oil and socioeconomic indicators for the four generic country categories

INDICATOR	ELECTRICITY PRODUCTION FROM OIL	MOTOR VEHICLES	URBAN POPULATION	GINI COEFFICIENT	POVERTY RATE AT $2 A DAY
UNITS	% OF TOTAL	PER 1,000 PEOPLE	% OF TOTAL	INDEX	% OF POPULATION
YEAR	2009	2009	2010	2009	2010
LIC average	32	19	30	40	71
LMIC average	21	75	44	42	36
UMIC average	19	197	62	43	8
OEC average	26	92	57	40	33
Correlation with GNI per capita (importers only)	-0.17	0.81	0.65	0.17	-0.76

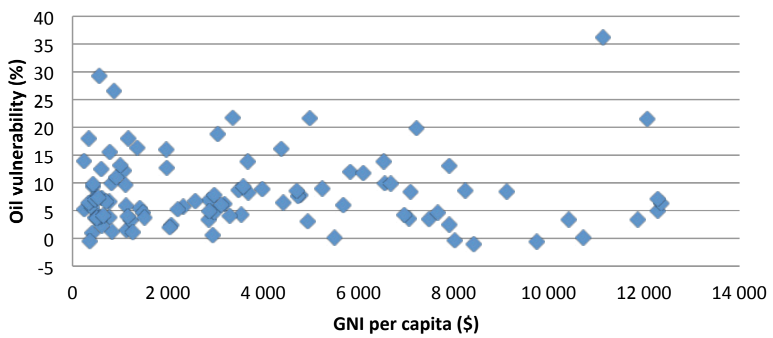
SOURCE: Own calculations based on World Bank (2012)

Table 1-6: Summary of oil vulnerability indicators for net oil importers

INDICATOR	OIL VULNERABILITY	OIL IMPORT DEPENDENCE	OIL VULNERABILITY	OIL IMPORT DEPENDENCE	OIL INTENSITY	ENERGY INTENSITY
DESCRIPTION	OIL EXPENDITURE/ GDP	OIL IMPORTS/ OIL USE	OIL EXPENDITURE/ GDP	OIL IMPORTS/ OIL USE	OIL USE/ ENERGY USE	ENERGY USE/ GDP
UNITS	%	%	%	%	%	BTU/$
Year	2011	2011	2008	2008	2008	2008
LIC average	8	95	8	98	71	9 685
LMIC average	7	83	8	82	59	14 152
UMIC average	8	79	7	77	59	9 573
Average for all	8	85	8	85	63	11 220

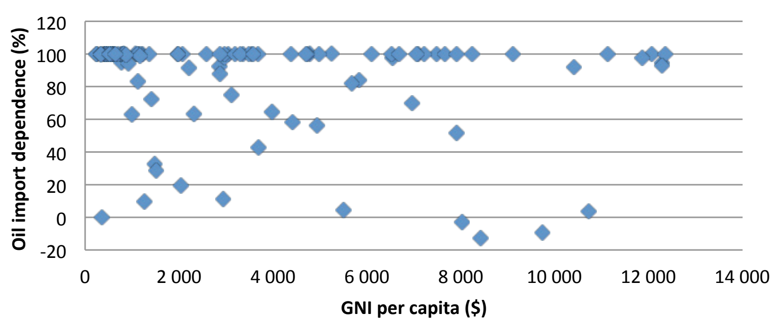
SOURCE: Own calculations based on EIA (2012) and World Bank (2012)

Figure 1-75: GNI per capita and oil vulnerability in net oil importers, 2011



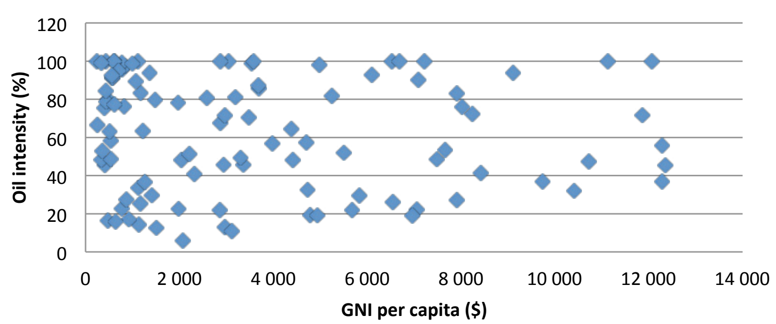
SOURCE: Own calculations based on EIA (2012) and World Bank (2012)

Figure 1-76: GNI per capita and oil import dependence in net oil importers, 2011



SOURCE: Own calculations based on EIA (2012) and World Bank (2012)

Figure 1-77: GNI per capita and oil intensity in net oil importers



SOURCE: Own calculations based on EIA (2012) and World Bank (2012)

The relationship between oil vulnerability (expenditure on oil as a percentage of GDP) and per capita income is represented graphically in Figure 1-75 below. Clearly, there is no discernible pattern, which shows that factors other than income per head drive oil vulnerability. Chief amongst these factors is oil import dependence.

Figure 1-76 shows that while the degree of oil import dependence varies greatly across net oil importing developing countries, the vast majority of them rely on imports to meet more than half of their oil consumption. Furthermore, some 66 out of the sample of 105 countries are completely reliant on imported oil.

Figure 1-77 illustrates that the degree of oil intensity (i.e., the extent to which a country relies on oil to meet its energy needs) varies widely across countries, with no particular association with income level being evident.

Figure 1-78 shows that there is a large degree of variation in oil consumption per person for different per capita income levels, particularly amongst the upper middle income countries. Notably, four of the major outliers in terms of per capita oil consumption are SIDS that rely heavily on oil for electricity generation.

Statistical regression analysis revealed that the following variables are statistically significant in explaining the variation in oil consumption per capita (see Appendix 5.1):

- income per capita;
- average of diesel and petrol prices (which are negatively associated with oil consumption, as expected);
- motor vehicles per 1,000 people; and
- the percentage of electricity produced from oil.

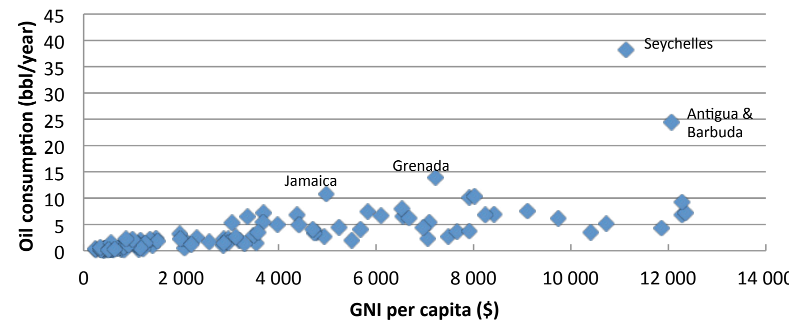
Together, these four variables explain 65% of the variation in oil consumption per capita for a sample of 59 oil importing countries (which had data observations for all the variables). However, the following variables had no additional statistical explanatory power for per capita oil consumption:

- percentage contribution of industry to GDP;
- urbanisation rate;
- oil import dependency (oil imports as a percentage of total oil consumption).

Further analysis confirmed that the urbanisation rate (41%), motor vehicle prevalence (65%) and oil consumption (45%) are all relatively well explained statistically by income level (where the percentage is the adjusted coefficient of variation in a simple regression of each variable on income). It should be noted, however, that the direction of causality cannot be inferred from these coefficients; for example, the causality between income and urbanisation could run in both directions. Other determinants of oil consumption might include factors such as cultural preferences, topographical features of the countries, and historical policy decisions concerning transport infrastructure.

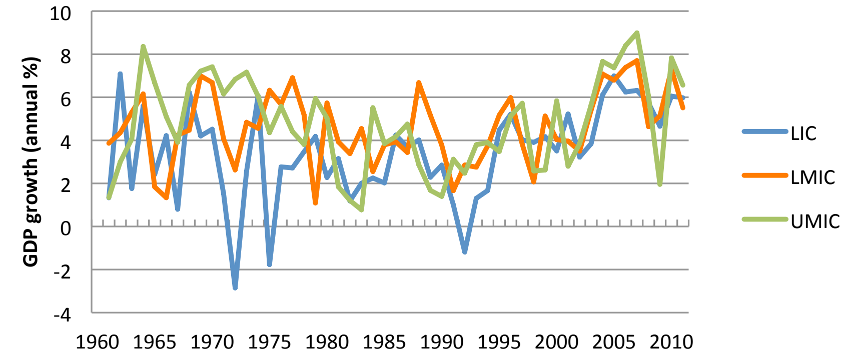
Figure 1-79 shows the average annual GDP growth rates for the three groups of net oil importing countries. The time series were obtained by simple averaging of all the countries in each group, without weighting each country's growth rate by the absolute size of its economy. These growth rates give some indication of how oil importing developing countries weathered historical oil price shocks. Growth rates in all three income groups were little affected in the year following the first oil shock in 1973/74, but slowed markedly in 1975, especially in LICs. Economic growth did slow again in the year of the second oil shock (1979), especially in LMICs and UMICs where GDP grew 2.5 percentage points more slowly than in 1978. Growth rates remained below trend in 1980, but few countries in each of the three groups experienced an outright recession, in contrast with many of the high income countries. The very short-lived oil price spike in 1990 has no discernible impact on growth rates in developing countries. The more drawn-out oil price shock of 2005-2008 did not dampen developing country growth rates much, as they benefited from the boom in the global economy and commodity prices at that time. However, GDP growth rates slowed markedly in 2009 as the recession in the OECD countries spilled over to the developing world, and on average UMIC economies contracted in that year. Nonetheless, economic growth rebounded in 2010 and 2011, despite the high oil prices. Historically, therefore, it appears that developing countries have been much less susceptible to oil price shocks than the industrialised countries, which generally have much higher rates of oil consumption per person.

Figure 1-78: Gross national income and oil consumption per capita in net oil importers, 2011



SOURCE: Own calculations based on EIA (2012) and World Bank (2012)

Figure 1-79: Average GDP growth rates in net oil importing country groups, 1960-2011



SOURCE: Own calculations based on World Bank (2012)

A summary of the socioeconomic characteristics, oil dependencies, and likely impacts of oil shocks across the four generic categories is provided in Table 1-7.

Table 1-7: Summary of vulnerabilities and impacts for the four generic country categories

COUNTRY CATEGORY	SOCIOECONOMIC CHARACTERISTICS	OIL DEPENDENCIES & VULNERABILITIES	LIKELY IMPACTS OF OIL PRICE SHOCKS
Low income	■ undiversified economies with large agriculture sector ■ high degree of reliance on world trade for both commodity exports and manufactured imports ■ extremely high rates of poverty and undernourishment ■ moderate to large current account deficits and external debt/GDP ratios	■ very low oil consumption per person ■ moderately high oil vulnerability ■ moderate oil resource dependency ■ very high oil import intensity	■ deteriorating balance of payments and terms of trade ■ decline in production & GDP growth ■ rise in producer and consumer price inflation ■ broadening and deepening of poverty and food insecurity ■ possible social upheaval
Lower-middle income	■ large contribution of energy-intensive industry ■ comparatively low levels of foreign reserves in relation to external debt ■ large current account deficits and a high level of dependence on international trade ■ moderately high incidence of poverty ■ large urban poor populations	■ low levels of oil consumption per person ■ moderately high oil vulnerability ■ very high oil resource dependency ■ high oil import intensity ■ transport infrastructure highly reliant on oil	■ growing current account deficit ■ slowing GDP growth and employment creation ■ rise in price inflation, especially for transport and food items ■ increasing rates of poverty and inequality ■ growing food insecurity, possibly undermining social cohesion
Upper-middle income	■ relatively extensive trade and financial integration with high income countries ■ moderate to large current account deficits and external debt to GDP ratios ■ relatively high average urbanisation rate and prevalence of motor vehicles	■ moderate oil consumption per person ■ moderately high oil vulnerability ■ very high oil resource dependency ■ high oil import intensity ■ transport & settlement infrastructure heavily dependent on oil	■ growing current account deficit and financial account outflows, resulting in exchange rate volatility ■ slowing GDP growth and job losses in vulnerable sectors ■ rising cost of living and constrained mobility for many households ■ possible systemic crises in critical systems if oil shortages arise
Oil exporters	■ highly variable incidence of poverty, inequality and unemployment ■ evidence for oil exports improving socioeconomic conditions is mixed: there is some evidence to suggest that oil production is linked to lower poverty levels and greater development; ■ but higher oil production has not, by and large, reduced unemployment rates, possibly due in part to reduction in employment in non-oil sectors	■ several African countries and small island development states are heavily reliant on oil for export and government revenues, including: Congo, Sudan, Angola, Nigeria and Timor-Leste ■ other more developed economies are heavily reliant on oil for domestic consumption: e.g. Iraq, Iran, Turkmenistan, Yemen, Libya Venezuela ■ risk of declining oil revenues in countries whose net oil exports are declining due to rising consumption and/or depletion, although mitigated by rising oil prices	■ macroeconomic instability arising from oil price volatility ■ there is some, but case specific, evidence for the 'resource curse' amongst oil exporting economies, with appreciating exchange rates ('Dutch disease'), adverse impacts on manufacturing and non-tradables ('crowding out'), weak institutions and governance as well as symptoms of anarchy and even civil war ■ discovery of oil increases the risk of, and has also led to, secessionist violence in a number of countries ■ negative socioeconomic impacts of rising world prices for food and manufactured goods

The analysis also identified three special groups of oil importing countries, which cut across the income categories. Their particular vulnerabilities are summarised in Table 1-8. Some of the oil exporting countries are also fragile states and share these vulnerabilities.

Table 1-8: Summary of vulnerabilities in special country categories

LANDLOCKED COUNTRIES	SMALL ISLAND DEVELOPING STATES	FRAGILE STATES
■ little or no oil refining capacity ■ end of the fuel supply chain ■ high transport costs for fuel & other traded goods ■ high average fuel prices	■ very high oil resource dependency ■ extremely high dependence on oil for electricity ■ little or no oil refining capacity ■ end of the fuel supply chain ■ lack of economies of scale ■ little geopolitical power	■ weak state capacity ■ low state legitimacy ■ prone to violent conflict ■ infrastructure vulnerable to interference

Part 2 of the report will draw on the insights gained in this assessment of oil shock vulnerabilities, as well as the four case studies, to develop a set of generic national oil mitigation strategies for developing countries.

part 2.

OIL SHOCK MITIGATION STRATEGIES

OIL SHOCK MITIGATION STRATEGIES

2.1 Introduction

This second part of the report investigates appropriate mitigation strategies and policies for countering the adverse socioeconomic impacts of oil price and supply shocks. In this introductory section, we discuss the conceptual context in terms of building socioeconomic resilience and fostering sociotechnical transitions, describe the analytical framework that is used to structure the mitigation strategies across the four generic country categories, and briefly outline the remainder of Part 2.

2.1.1 Conceptual background

In the introduction to this report, it was shown that in recent years the balance between demand and supply in the international oil market has become very tight, signalling the end of the era of cheap oil (IEA, 2011a). Furthermore, it was argued that oil shocks are likely to be more frequent and more severe in the future because the world is very likely near or perhaps already at the all-time peak in world conventional oil production, because net world oil exports appear to have peaked several years ago, and because unconventional oil sources are more costly to access both economically and energetically. The extensive threats posed by growing global oil scarcity (as detailed in Part 1 of the report) present a strong **pragmatic rationale for government-led initiatives to mitigate the harmful socioeconomic effects of international oil price and supply shocks.**

Mitigation in the context of this report refers to strategies, policies and measures formulated and implemented to proactively lessen any future negative impacts of oil scarcity and price shocks, chiefly by reducing reliance on imported oil. A closely related goal is adaptation, which implies coping with higher oil prices and making do with less oil, i.e. reacting to evolving circumstances as global oil supplies deplete. The key difference between mitigation and adaptation as the terms are used in this report is that the former refers to actions that are taken *in advance of shocks*, while adaptation deals with reactive measures taken *after* shocks have occurred. Given the oil price shocks that have occurred in recent years (2008 and 2011-2012), countries are already having to adapt to a new era of triple-digit oil prices and heightened oil price volatility.

Oil shocks involve both **uncertainty and risk**. There is considerable uncertainty about the nature of future oil shocks, including their timing and duration, magnitude (e.g. percentage rise in the oil price or percentage reduction in oil import supply volumes), the severity of impacts, and the responses of various agents (e.g. domestic consumers and firms, governments in other countries, and multilateral institutions). Oil shocks fall into a category of risks that have been labelled "external risks", which by their nature are complex and beyond the capacity of a single nation or organisation to manage and control (Kaplan & Mikes, 2012).[11] The World Economic Forum (WEF, 2013) recommends that the most appropriate approach to dealing with uncertain external risks (including global oil shocks) is to foster *resilience*.

The term **resilience** was originally introduced in the context of ecological systems by Holling (1973) and has subsequently been applied in the study of social-ecological systems. Social-ecological systems in turn refer to linked human socioeconomic systems and natural ecosystems, recognising that the former are inseparable from the latter. The socioeconomic systems devised by human societies are special cases within the broader class of complex adaptive systems studied by systems theorists. Complex adaptive systems are characterised by nonlinear cause-effect relationships with possible time delays, moving thresholds and tipping points, and the possibility of multiple equilibrium states. Within this theoretical context, resilience has been defined as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (Walker, Holling, Carpenter & Kinzig, 2004: 5). According to Rees (2010: 5), resilience science recognises that social-ecological systems are perpetually changing in response to both external and internal forces, such that "attempts to resist change or control it in any strict sense are doomed to failure." In the context of oil shocks and global oil depletion, the concept of resilience has been employed extensively within the so-called "transition movement" (see for example Hopkins, 2008; 2011; Rees, 2010). More recently, resilience has been adopted as a central concept in the World Economic Forum's (WEF) annual global risk assessment (see WEF, 2013). Their approach defines a resilient country as "one that has the capability to 1) adapt to changing contexts, 2) withstand sudden shocks and 3) recover to a desired equilibrium, either the previous one or a new one, while preserving the continuity of its operations" (WEF, 2013: 37).

11 The other two risk categories identified by Kaplan and Mikes (2012) are "preventable risks" – process breakdowns and human error – and "strategic risks" – those that are incurred voluntarily after weighing them against the potential rewards.

For a socioeconomic system to be resilient, it requires several attributes (WEF, 2013):

- *robustness* (capacity to absorb and endure crises and perturbations);
- *redundancy* (having spare capacity and fall-back systems, particularly with respect to critical infrastructure and multiple solutions to emerging challenges);
- *resourcefulness* (the capacity to adapt to crises, responding innovatively, flexibly and with self-organisation);
- *responsiveness* (the capacity to mobilize rapidly when confronted by crises, which requires effective communication and inclusive participation)
- *recovery* (the capacity to stabilise after a shock and to adapt to new conditions).

Rees (2010) suggests in addition that resilience requires *diversity* of the economy and employment opportunities (e.g. a competitive economic environment involving multiple actors or firms) as well as an enhanced degree of *regional self-reliance*. The specific requirements for resilience in the face of oil shocks will be explored in the sections that follow.

While resilience provides a useful organising principle for responding to external risks and preparing for uncertain shocks, an effective approach to mitigating oil shocks in the context of on-going global oil depletion also requires an understanding of energy transitions in particular and societal transitions more broadly. A useful body of literature which has emerged over the past two decades considers the interaction of human societies and natural systems within integrated **social-ecological systems** (e.g. Fischer-Kowalski, 1998; Fischer-Kowalski & Haberl, 2007). A central concept in this literature is the "metabolism" of a society, which refers to the ways in which materials and energy are used to satisfy human needs and wants. Three historical **socio-metabolic "regimes"** are identified, namely hunter-gatherer, agrarian and industrial societies. Each regime is based on a certain way of obtaining and using energy: hunter-gatherer societies rely on passive solar energy embodied in wild plants and animals; agrarian societies actively capture solar energy via cultivated plants and livestock; and the key energy resource underpinning the modern industrial socio-metabolic regime is fossil fuels (coal, oil and natural gas).

In the socio-ecological systems perspective, the depletion of oil (and other fossil fuels), together with the need to reduce environmental impacts of material and energy use, implies that the industrial socio-metabolic regime must inevitably undergo a **transition** to a sustainable socio-metabolic regime that is based on renewable energy sources (Haberl *et al*., 2011; Fischer-Kowalski & Haberl, 2007; Fischer-Kowalski, 2011). This view posits that a regime change will be driven either unintentionally as a consequence of resource depletion and/or pollution, or as an intentional change chosen by society (Fischer-Kowalski, 2011). The outcome could either be systemic collapse, or a successful transition to sustainability, depending in large part on whether alternative resources and opportunities become available in time. Wakeford (2012) argues that the peak and decline in world oil production (followed several decades hence by peaks in coal and natural gas) represents a specific catalyst that will force a transition from the fossil fuel-based industrial regime to a regime founded on renewable energy sources. It is therefore imperative that countries adopt a long-term view when planning to mitigate oil shocks, as the latter will no longer be driven primarily by short-term exogenous political events, but rather by the long-term, structural forces of resource depletion.

The socio-metabolic regime perspective has interesting implications for the three income-based categories of developing countries. Low income countries are centred mostly within the agrarian regime, as evidenced by the high percentage of the working population that are engaged in agriculture. Lower middle income countries have typically begun the agrarian-industrial transition, moving into various heavy manufacturing industries. Upper middle income countries have in general progressed further towards the industrial metabolism and are therefore more highly dependent on fossil fuels, although most have not completed the transition as have the "industrialised" or high income countries of North America, Europe, East Asia and Oceania. The implications of these different stages of energy transition will be spelled out in later sections.

A number of lessons about **energy transitions** have been drawn from historical research (see Grubler, 2012 for a review). First, the manner in which energy services are used, rather than the raw sources of energy themselves, are often key drivers of energy transitions. For example, in a study of historical examples of energy transitions for various services and sectors, Fouquet (2010: 6586) found that the "main economic drivers identified for energy transitions were the opportunities to produce cheaper or better energy services". While Fouquet focused on transitions to low-carbon energy sources, mainly motivated by mitigation of climate change, our concern in this report is with energy transitions stimulated by growing oil scarcity and rising oil prices, which will help to fulfil Fouquet's first condition (cheaper energy) by making many renewable energy sources more competitive on price. However, this may be counteracted to an extent by adverse economic conditions resulting from oil price shocks, which will militate against R&D and rapid deployment of alternatives. Fouquet's second condition (an improvement in services), may occur in some instances (e.g. less pollution from electric vehicles), but is likely to be of secondary importance.

The second insight from history is that past energy transitions (principally from biomass to coal, oil and gas) have been very gradual, taking several decades at least and in some cases over a century (Smil, 2010). However, the information and communication technology revolution could facilitate more rapid energy transitions in the future (Fouquet, 2010: 6594). Third, "historical research has identified that invariably all successful scale-ups of energy technologies required a prolonged (several decades) period of experimentation and learning that operates at comparatively small levels of unit as well as industry scale, before successful scaling-up can be achieved" (Grubler, 2012: 14). Late-comers may be able to make transitions more rapidly than pioneers, as they can adopt newer technologies and practices. In that sense, low and lower middle income countries seem to have a relative advantage over wealthier countries that are more heavily invested in fossil fuels. At a policy level, it is suggested that governments need to provide protection for niche markets in order to overcome the free rider problem, and also avoid possible early lock-ins to undesirable technologies (Fouquet, 2010: 6594). For those countries consuming large quantities of fossil fuels, Smil (2010) advocates an aggressive programme to improve the efficiency of energy conversion combined with declining per capita rates of energy consumption. Nevertheless, Grubler (2012) notes that research into energy transitions in developing countries remains scant.

The notion of managed transitions to sustainable socioeconomic regimes (involving energy transitions) begs the question of who or what entity performs the management. The mitigation strategies developed in this report are aimed primarily at national governments in developing countries, although some of the policies and measures that are recommended would be implemented by provincial or local governments, and some of the strategies require regional coordination among a number of sovereign states. Many governments in developing countries already qualify as or aspire towards being a **developmental state**, which may be defined as "a state that intervenes to promote economic development by explicitly favouring certain economic sectors over others" (Chang, 2010: 83). In the context of this report, it is envisaged that developmental states would actively mitigate future oil price and supply shocks, partly through preparing and implementing sustainability transition plans. However, many developing countries, especially among the lower income categories, lack many of the capacities required for a truly developmental state. Hence each state will need to play to its own particular strengths and confront its own particular weaknesses and challenges.

2.1.2 Research questions

The overarching question tackled by Part 2 of the report is as follows:

- What strategies can developing country governments adopt in order to most effectively mitigate the negative socioeconomic impacts of global oil price and supply shocks?

More specifically, this part of the report examines the following more detailed questions:

- What are the most viable and sustainable substitutes for imported oil?
- How can the transport system be transformed to reduce its oil dependency?
- How can the oil dependency of the agricultural system be attenuated and its resilience to oil shocks be improved?
- What macroeconomic policies can increase the economy's resilience to oil shocks?
- How can basic human needs be met and social cohesion maintained in the face of oil price and supply shocks and constrained mobility of people and goods?

2.1.3 Analytical framework

The development of mitigation strategies (including more detailed policies and measures) in this part of the report has several organising principles.

First, we use the **four generic country categories**, namely: (1) low income oil importing countries, (2) lower middle income oil importing countries, (3) upper middle income oil importing countries and (4) net oil exporting countries. The remainder of this section outlines the framework applied for net oil importing countries; the oil exporter category of countries is fundamentally different and thus requires its own analytical structure, which is explicated in section 2.5.

Second, there are five **subsystems** (which may also be seen as policy domains) of the national socioeconomic system that have been identified as particularly important when considering oil shocks in oil importing countries, namely the energy system, the transport system, agriculture and food production, macro-economy, and social welfare. These five subsystems were also used as the organising rubric in the oil importing country case studies.

The third organising principle is the **temporal dimension**. Mitigation strategies, policies and measures are categorised as short-term (e.g. preparations, policies and regulations for dealing with sudden oil price spikes and/or supply shortages) or long-term (e.g. investments in long-lived infrastructure for non-oil energy and transport systems, and implementation of policies designed to influence the structural orientation and development path of the economy so that it becomes more resilient and sustainable).

Fourth, as discussed in the introduction to Part 1 (section 1.1), this report deals with two **types of oil shocks**, namely: (1) oil price shocks, i.e. rapid increases in the international price of crude oil, which may be temporary or sustained; and (2) supply shocks, i.e. sudden physical shortages of crude oil and/or petroleum products such as petrol and diesel fuel. Both types of shocks are likely to occur in a cumulative manner once world oil production begins its inevitable decline phase. However, in some cases different mitigation strategies are required for the two types of oil shock.

Mitigation options are discussed according to the generic way in which they attempt to **influence human behaviour** to bring about change in a desired direction. There are essentially three such ways, namely education and awareness campaigns, the use of economic incentives (such as taxes and subsidies), and coercion in the form of statutory regulations prescribing and proscribing certain behaviours or actions on the part of individuals, communities and firms.

Finally, **obstacles** to and **constraints** on the implementation of the mitigation strategies proposed for each of the generic country categories are identified within seven categories: cultural-ideological, behavioural–psychological, social, political, institutional, economic and environmental (see van den Bergh *et al.*, 2011).

2.1.4 Outline of Part 2

The remainder of Part 2 is organised as follows. Each of the four major sections 2.2 through 2.5 deals with oil shock mitigation strategies in one of the four generic developing country categories, namely: (1) low income oil-importing countries, (2) lower middle income oil-importing countries, (3) upper middle income oil-importing countries and (4) oil exporting countries. Although there is a large degree of overlap among the strategies considered for each of the oil-importing country categories, the discussion highlights differences in their relevance and feasibility according to income level and other factors. Section 2.6 contains a comparative summary, highlighting the key similarities and differences among the recommended strategies for the four country categories, and presents the main conclusions.

2.2 Low Income Countries

This section presents oil shock mitigation strategies for low income countries (LICs), defined by the World Bank as those with gross national income (GNI) per capita of less than $1,025 in 2011. The following five subsections deal with strategies, policies and measures in five subsystems of the national socioeconomic system, namely: energy, transport, agriculture, macro-economy and society. The sixth subsection provides a concise summary of the recommendations, and discusses obstacles and constraints that may limit the implementation of the mitigation strategies.

CREDIT: BIO ENERGY RESOURCES LIMITED

Malawians picking Jatropha nuts

CREDIT: BIO ENERGY RESOURCES LIMITED

Press for manufacturing biodiesel in Lilongwe, Malawi

2.2.1 Energy

The energy system obviously bears the brunt of oil shocks, and is therefore a crucial domain for response plans. These are divided between short-term strategies, which aim to provide an immediate buffer during episodes of oil price or supply shocks, and long-term strategies that seek to minimise a country's exposure to oil shocks.

Short-term strategies

INSULATE THE ECONOMY FROM EXCESSIVE OIL PRICE VOLATILITY AND PHYSICAL SUPPLY SHORTAGES.

When faced with spikes in international oil prices, LICs face two options: allowing full pass-through of price increases to domestic fuel prices, or subsidising end-user prices (AfDB, 2009: 152-155). Full and immediate pass-through of international price increases can be economically damaging, especially if there is a high degree of price volatility that creates uncertainty for businesses and consumers. To counter this, governments can implement a **fuel pricing mechanism** that evens out short-term price volatility, for example by applying a three-month moving average of fuel prices. However, this will require financing mechanisms and periodic price adjustments, which require both administrative capacity and adequate liquidity in government finances, both of which may be constrained in some LICs. If the oil price spike is short-lived, there may be a case for temporary **subsidies** in order to minimise the disturbance to the economy. However, it is argued in this report that oil price shocks are likely to become more frequent, persistent and cumulative as oil resources continue to deplete, which would make continued subsidies unaffordable to governments operating under tight budget constraints. Subsidies also encourage continued dependence on oil, which will undermine the long-term strategies for increasing oil independence that are discussed below. However, if LICs are to phase out existing petroleum fuel subsidies, it is recommended that they introduce ameliorate measures to protect poor households that have high dependency on such fuels (Baig *et al*., 2007).

Resilience to short-term fuel shortages requires sufficient **strategic fuel stocks** to enable continued functioning of the transport system. Landlocked countries are most in need of strategic oil stocks, given their limited sources of supply and vulnerable position at the end of supply chains. Resilience can be enhanced through the establishment of strategic oil reserves, which ideally would be filled in times of relatively low oil prices. Each of the 28 member countries of the International Energy Agency (all of which belong to the Organisation for Economic Cooperation and Development) is required to hold oil stocks equivalent to 90 days of its net oil imports of the previous year. However, oil storage facilities have high installation and maintenance costs, which may be prohibitive for many LICs. According to the African Development Bank, for instance, "most of the [African] countries do not have, or cannot afford to have, any sizable oil inventory" (AfDB, 2009: 167). This is particularly the case in countries that have no oil refining capacity and that rely wholly on imports of refined fuels, which applies to the majority of LICs (see section 1.2). In addition, governments may introduce legislation that requires petroleum product retailers to maintain certain levels of stocks, e.g. sufficient for a given number of days of typical consumption (AfDB, 2009: 157). However, there must be an agreed mechanism to compensate retailers for the costs of maintaining such stocks, probably through higher fuel prices. Whether it is the government or private oil companies that construct and maintain fuel storage facilities, ultimately the cost has to be traded off against the risk of serious economic losses in times of fuel shortages.

A third near-term strategy is to pursue **regional cooperation** in energy matters. This could involve forging closer ties with other oil-importing countries, for example by subscribing and contributing to a regional petroleum fund that acts as a pooled source of insurance to be made available when oil prices spike – an example being the African Petroleum Fund (AfDB, 2009: 217). Secondly, oil-importing LICs could attempt to form strategic alliances with oil-exporting countries, particularly those in their region.

Long-term strategies

REDUCE RELIANCE ON IMPORTED OIL THROUGH ENERGY CONSERVATION & DEVELOPMENT OF SUBSTITUTES.

In order to mitigate the impacts of oil price and supply shocks, the primary long-term goal for the energy sector is to reduce reliance on imported oil. There are two general strategies to achieve this goal, which should in general be implemented in tandem: (1) curtailment of demand for oil products through conservation and energy efficiency; and (2) a shift towards sustainable energy substitutes for imported oil.

Energy conservation and efficiency

As LICs typically consume very low levels of oil on a per capita basis, the scope for current energy conservation is limited (although these countries should ensure that future infrastructure and built environments are constructed in an energy-conserving manner). The pressing challenge for these countries is to expand the provision of modern energy services as rapidly as possible (Ebenhack & Martinez, 2009: 74). Nevertheless, there may be scope to improve supply-side energy efficiency at the upstream energy production stage (e.g. power generation) by utilising newer technologies. Efficiency gains that can be reaped at the downstream consumption stage of liquid petroleum fuels are discussed in the section on transport, below.

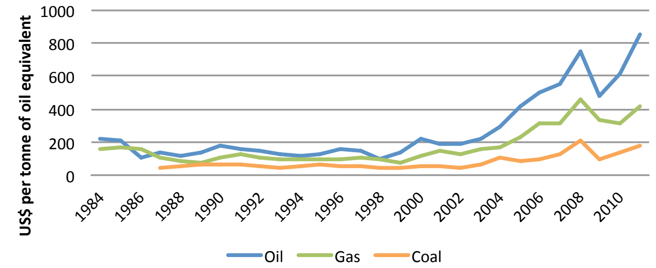
Substitutes for imported oil

The great challenge for LICs is to develop the means to harness indigenous sources of energy to replace imported oil. However, it must be stated at the outset that given oil's special characteristics and high quality as an energy carrier (e.g. high energy density, relatively high energy return on investment (EROI), ease of transport and storage), none of the alternative energy sources are perfect substitutes for oil (see Heinberg, 2009, for a review). Some energy sources – such as natural gas and liquid biofuels – can be more or less directly substituted for the main uses of oil, namely as liquid transportation fuels. Most of the other energy alternatives, such as electricity generated from renewable sources such as hydro, solar, wind and geothermal energy, are not direct substitutes for liquid petroleum fuels like petrol, diesel, jet fuel, paraffin and liquefied petroleum gas (LPG). Renewable electricity generation will need to be twinned with investment in electric grids and alternative transport infrastructure (which is discussed in the next subsection).

The obvious starting point for reducing reliance on imported oil is to consider the opportunities for developing **indigenous oil** resources, if these exist. Exploration for oil has increased markedly in many developing countries in recent years, as rising oil prices have offset risks and obstacles such as political instability and lack of infrastructure. This has yielded substantial new oil discoveries in some LICs, notably Tanzania and Uganda, which may even become net oil exporters within the next decade. If so, these countries will face the challenge of overcoming the resource curse and ensuring that the domestic population has access to a significant share of the oil. It is likely, however, that the majority of LICs will not find and develop significant oil reserves and will have to find other alternatives.

The closest energy substitute for oil is **natural gas**, which can replace oil in electricity generation, for heating, and even in transportation: compressed natural gas (CNG) can be used in motor vehicles after minor modifications to engines and storage tanks. Presently, natural gas trades at a discount to oil (in terms of common energy units) in most parts of the world (IEA, 2011c). It is also less harmful to the environment than oil, as it burns more cleanly and releases smaller quantities of carbon dioxide (IEA, 2012e). Until recently, of the net oil-importing LICs only Bangladesh had significant gas reserves, but even these are relatively small at 12.5 trillion cubic feet (BP, 2012). However, significant deposits of natural gas have been discovered in recent years in East Africa, including Mozambique, Tanzania and Madagascar (IOL News, 2012). These countries may become net exporters of natural gas within 5-10 years, provided sufficient investments in the gas industry are forthcoming from multinational companies. The challenge will be to ensure that the local populations also benefit from availability of gas for industrial and perhaps residential consumption. This is not guaranteed in the East African case, since the gas fields lie offshore and therefore most if not all of the gas might be shipped directly to export customers via liquefied natural gas (LNG) terminals. LICs without indigenous gas reserves may face insurmountable difficulties in accessing this energy source, since tapping into gas supplies relies on very costly pipeline or LNG infrastructure, which could be prohibitively expensive for most poor countries. In fact, Tajikistan and the Kyrgyz Republic, which benefited from Soviet-era pipeline networks, were the only LICs to import natural gas via pipeline in 2011 and none imported LNG (BP, 2012). Furthermore, international gas prices are fairly closely correlated with oil prices (see Figure 2-1). For most – if not all – other LICs, it is probably preferable to invest in indigenous renewable energy sources.

Figure 2-1: International oil, gas and coal prices, 1984-2011



SOURCE: BP (2012)

Coal, the dirtiest of the fossil fuels, can substitute for oil indirectly as a feedstock for thermal heat and power generation. It can also be converted into synthetic liquid fuels (coal-to-liquids, or CTL) via gasification and the Fischer-Tropsch process. However, CTL production requires very expensive capital investments and is probably not economically viable in LICs. It is also highly water-intensive, which may be detrimental to other end-uses such as agriculture, commerce and residential consumption. In any event, just three LICs have significant coal resources. Zimbabwe, which produced 2.5 million tonnes of coal in 2011 (BP, 2012), uses coal to generate electricity. There is scope for increased production (which stood at over 5 mt in the 1990s before the country's economic collapse), but this will require substantial investment. Neighbouring Mozambique has substantial coal reserves, which international mining companies have only begun to develop in recent years. The country looks set to become a significant net coal exporter in the years ahead, while domestic thermal power generation capacity is being developed by a private company (Wait, 2012). According to the United States Geological Survey (USGS, 2012), Afghanistan has "moderate to potentially abundant coal resources", but thus far their development has been hindered by conflict, difficult geology and topography, and a lack of transport and industrial infrastructure. Given these countries' low levels of economic development and the infancy of their coal mining industries, it is highly unlikely that any of them will be able to develop coal-to-liquid production capabilities in the foreseeable future. The best they can reasonably plan for is to increase coal-fired electricity generation. As for the remaining LICs that possess no domestic coal reserves, none are reported by BP (2012) to consume significant quantities of imported coal. Prospects for importing coal in the future are dimmed by the link between global oil and coal prices (see Figure 2-1 above), and by rising demand for coal in rapidly-growing East Asian economies, especially China and India, both of which are significant net coal importers.

Given the resource, economic and capital constraints on fossil fuel consumption by LICs, the best prospects for the majority of these countries lie in developing indigenous **renewable energy** (RE) sources, including biomass, liquid biofuels, biogas, hydro, solar, wind and geothermal energy. The main advantages of renewable energy sources are that they are inherently more sustainable than fossil fuels: they generally have much smaller carbon footprints, use far less fresh water, and are non-depleting (although still exhaustible in the case of biomass). Furthermore, the potential scale of many renewable energy resources is very large, at least on a global and regional basis (Resch *et al*., 2008), and some (especially solar and wind energy) are more widely distributed than fossil fuels. Renewable energy sources are also less likely to be exploited by foreign powers. Finally, RE costs tend to fall over time as technologies are improved, while fossil fuel prices tend to rise due to depletion and rising costs of production. Small-scale, decentralised renewable energy generation is a particularly attractive alternative to costly centralised grids in rural areas of LICs. However, RE sources also have several important limitations: (1) aside from biofuels, they cannot be directly substituted for liquid petroleum fuels as they provide electricity or heat; (2) the energy return on investment (EROI) ratio for most renewable energy sources is lower than historical ratios for fossil fuels (Lambert at al., 2012); (3) they currently require fossil fuels (and in some cases scarce minerals) for manufacture, distribution and maintenance; (4) the most abundant renewables, solar and wind, are intermittent sources of power that require storage mechanisms and/or load balancing on electrical grids; (5) most are found in low concentrations and thus produce energy on a much smaller scale than conventional power plants; and (6) in some cases the unit costs are still relatively high compared to fossil fuel energy (Heinberg, 2009; Cleveland, 2008). Nevertheless, research by a World Bank team shows that "most sub-Saharan African countries have renewable energy potential, technologically feasible to exploit with current technology, that is many times their current energy consumption" (Deichmann *et al*., 2010: 2).

Biomass – such as wood and agricultural waste – can be used to produce thermal energy (e.g. for cooking and heating, but also for industrial purposes) or to generate electricity. However, biomass energy is already used extensively (see section 1.2.2) and often unsustainably in most LICs, and often with deleterious impacts on the environment and public health (AfDB, 2009: 162). Deforestation and associated soil erosion is a growing problem in many LICs where the majority of the population relies on wood fuel for cooking and heating. In this context, increased use of biomass fuels to substitute for paraffin (derived from oil) could be a regressive step with unfortunate side-effects, unless mechanisms are introduced to ensure that harvests of biomass material are at or below sustainable yields. On the whole, LICs should aim where possible to develop more modern sources of renewable energy, in particular those that generate clean electricity. However, there is considerable scope to improve the efficiency with which biomass is currently used, for example through the adoption of efficient biomass cookers (World Bank, 2012b). There is also large unexploited potential for biomass combined heat and power (CHP) plants that utilise bagasse in sugar-producing countries. Such facilities already exist in several African LICs (e.g. Kenya, Tanzania, Uganda, and Zimbabwe) (REN21, 2012: 35). Biomass power plants are planned for Cameroon, Côte d'Ivoire, Ghana, Liberia, Rwanda, Senegal and Sierra Leone.

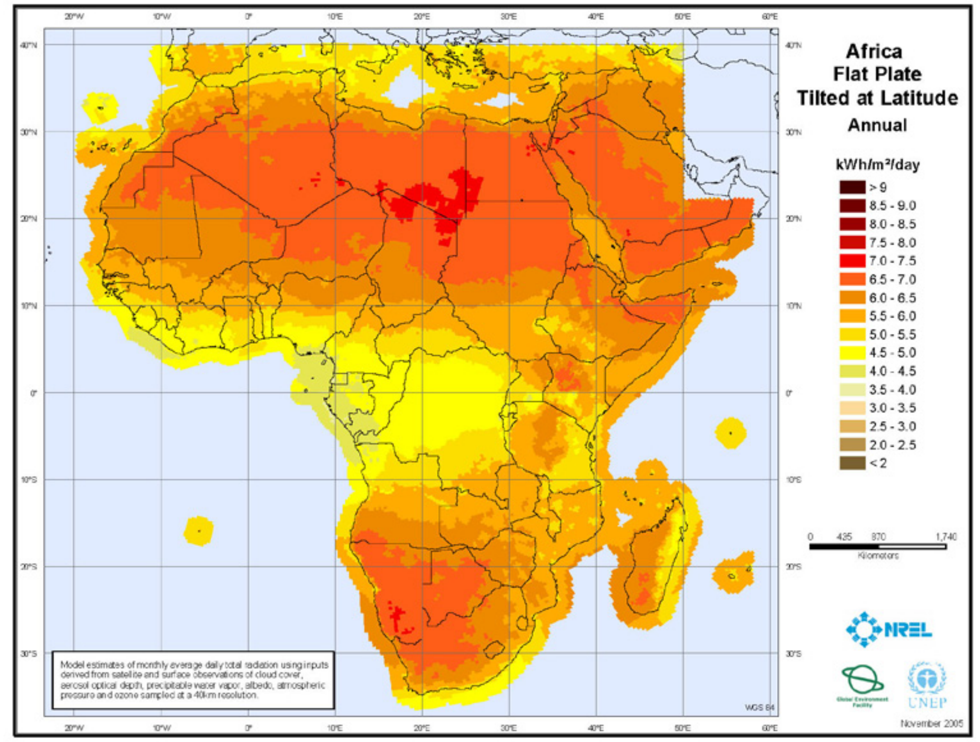
Biogas, a form of methane gas, can be produced efficiently from organic waste materials (including agricultural wastes, manures and sewage) and used for residential or even small-scale industrial purposes. Anaerobic biogas digesters can operate efficiently on a small, local scale, and are ideal for rural agricultural settings where the resultant biogas can be used for household cooking and heating. Production of biogas also yields useful by-products such as organic fertilisers. Capital costs represent the largest component of biogas costs, while operation and maintenance costs are relatively low and the feedstock is often free as it consists of various waste materials (Amigun *et al.*, 2008: 702). Importantly in LICs, biogas can relieve pressure on forest resources.

Liquid biofuels are the most direct renewable energy substitute for petroleum-derived transport fuels such as petrol and diesel. Ethanol, produced from crops such as corn, sorghum and sugar cane, can be blended with conventional petrol in low ratios and used in existing internal combustion engines (ICEs), or used in up to 100% concentration in modified ICEs. However, ethanol distilleries need to be large scale in order to be efficient, and the large capital costs may be an obstacle in many LICs. Biodiesel can be manufactured from various oil-bearing crops (including soybeans, palm oil, canola, sunflower and the fruits of the Jatropha tree) and can be blended with conventional diesel or used alone in diesel engines. A big advantage of biodiesel is that it can be produced efficiently on a small, local scale and therefore requires smaller capital outlays compared to ethanol (Nolte, 2007). A domestic (and indeed the global) biofuel market could help to make small-holder farmers in LICs more commercially viable by raising the price of their feedstock crops.

However, biofuels have a number of important drawbacks. The main disadvantage of current-generation biofuels is that they may undermine food security either by consuming food crops or by taking land and water resources away from food production (Brown, 2008). Another is that grain-based ethanol and biodiesel made from some crops have at best marginal net energy yields (Murphy *et al.*, 2010). Currently, biofuel production is practically non-existent in LICs (see BP, 2012), and given that the majority of LICs already depend on food aid (WFP, 2012), it seems unlikely that first generation biofuels that rely on grain feedstock could become a viable substitute for petroleum fuels in the foreseeable future. In fact, there is a risk of arable land in LICs being leased to foreign companies that produce biofuels for consumption in high income countries, further compromising domestic food security (Brown, 2012). A possible exception is ethanol produced from sugarcane in subtropical countries such as Mozambique and Malawi. The latter country already produces 5% of its liquid

Hydroelectric power is one of the oldest and best established sources of renewable energy, produced in over 150 countries and constituting the world's largest source of renewable electricity (REN21, 2012). Hydropower is a mostly reliable and relatively cheap source of base-load electricity. The vast majority of hydropower is generated on a large scale using water stored in dams or run-of-river flows. Although large-scale hydro requires large initial capital outlays for dam and turbine construction, the operating costs are relatively low since there is no feedstock cost, and plants have a long lifespan – typically over 50 years. Moreover, hydro plants at dams have a built-in energy storage facility, which provides a back-up for intermittent RE like solar and wind.

Figure 2-2: Solar radiation in Africa



SOURCE: U.S. National Renewable Energy Laboratory

On the downside, dams can be damaging to the local and downstream environments and sometimes displace whole communities. Severe droughts have in recent years curtailed hydropower generation in some regions, e.g. in East Africa and South Asia. Lately smaller-scale 'run-of-river' hydro schemes have been gaining traction in many developing countries, especially in rural areas. Almost all of the LICs currently generate part of their electricity from hydropower, with the proportion nearing 100% in countries like Nepal, Mozambique and Tajikistan. Nevertheless, there is significant scope for new large-scale hydropower in many LICs – particularly in Africa, where a lack of finance and in some cases political instability has thwarted its development. It has been estimated that less than 10% of Africa's hydropower potential has been tapped (Deichmann *et al.*, 2010: 23). However, several collaborative hydro projects involving various groups of East African countries are currently under way (REN21, 2012: 42). Chinese banks are funding hydro developments in Africa, with the projects often implemented by Chinese companies. A 193 MW hydro plant was recently built in Cambodia by a Chinese company (REN21, 2012: 42). An estimated 40 gigawatts (GW) of hydropower capacity remains untapped in the Democratic Republic of Congo after decades of adverse political conditions.

Solar energy can be utilised in a variety of ways for various purposes, including heating of space and water, and production of electricity. Solar energy is an especially attractive energy source in LICs, given that many of these countries (particularly in Africa and Central Asia) have ample solar resources (see Figure 2-2). Solar thermal energy is particularly well suited to LICs since it does not require costly distribution grids and can be used in rural areas. Solar water heaters (SWHs) are a tried and tested technology whose use is expanding rapidly in many developing countries, although mostly in those with higher household incomes (REN21, 2012). SWHs offer an alternative to unsustainable biomass use in LICs. Similarly, a wide range of simple, relatively inexpensive solar cooker technologies have been developed, which are ideal in rural LIC contexts where traditional fuels (wood and dung) are scarce and their use is contributing to deforestation and soil erosion (Solar Cookers International, 2013). Furthermore, solar lanterns can replace paraffin and candles for lighting (REN21, 2012: 82). Electricity may be generated from solar energy via photovoltaic (PV) cells, either connected to electric grids or (less commonly thus far) as stand-alone installations. Solar energy is an abundant, renewable resource in most countries.

The main weaknesses of solar PV power are its intermittency, which requires storage and/or back-up systems, and the reliance for manufacture of solar panels on scarce rare earth elements (Klare, 2012). While solar PV is still expensive compared to many other forms of electricity, the costs of PV modules have fallen dramatically in recent years, including a drop of around 40% in 2011 following China's aggressive entry into the PV manufacturing business (UNEP, 2012). Solar PV capacity is negligible or non-existent in the majority of LICs, but this situation may begin to change if the rapid price declines for PV modules recorded in recent years continue. One exception is Kenya, which in 2011 became home to the largest solar PV system (0.5 MW) in sub-Saharan Africa (REN21, 2012: 49). The other technology for converting solar energy into electricity is concentrated solar power (CSP), which involves arrays of mirrors that reflect the sun's rays onto a central tower to create steam that drives a turbine which generates electricity. At this stage, CSP is still prohibitively costly for LICs, but in some cases foreign firms may in the future invest in CSP plants in sun-rich LICs, e.g. in the north African countries of Mauritania and Mali.

Wind power has been one of the fastest-growing energy sources in the world in the past decade, with growth averaging over 25 per cent a year (BP, 2012). Wind power has now become cost competitive with coal-fired electricity in some parts of the world, including a large part of Ethiopia (Deichmann *et al.*, 2010: 22). As yet few LICs have significant wind power capacity (BP, 2012), although Ethiopia constructed its first commercial scale wind farms in 2011 (REN21, 2012: 57). One of the constraints on wind power in an LIC context is the need for expensive electricity grids and/or storage and back-up capacity that is needed to compensate for the intermittency of wind energy. Nevertheless, small-scale turbines and small networks hold potential for power generation in rural areas (REN21, 2012: 58).

Geothermal energy stored in underground rocks and water or vapours can be used to generate electricity or for heating. Conventional geothermal power generation is restricted to countries with suitable geological features, such as those lying along the East African Rift Valley (see Figure 2-3). As

Figure 2-3: Map of developing countries with installed geothermal power capacity

SOURCE: REN21 (2013)

of 2011, Kenya (170 MW) and Ethiopia (7 MW) were the only LICs with installed geothermal power capacity (BP, 2012), but several other countries in the region (Djibouti, Eritrea, Rwanda, Tanzania and Uganda) have recently initiated plans to develop geothermal energy resources (REN21, 2012: 41). Geothermal heat can also be tapped at differing temperatures for a wide range of uses including heating of water and greenhouses (IEA, 2011b).

Clearly, there is a need to plan "contextually appropriate energy mixes" in each of the LICs (Ebenhack & Martinez, 2009: 78). This will depend *inter alia* on local resource availability, demand projections, and the identification of locally appropriate technologies, and will require multidisciplinary teams of experts drawing on indigenous knowledge.[12] For example, water-scarce countries in the Sahel have little potential for hydropower, but abundant solar energy resources. In countries which have fossil fuel reserves, these should ideally be utilised in conjunction with renewable energy sources from the outset (Ebenhack & Martinez, 2009: 79). Given the extremely low levels of rural energy consumption in LICs relative to wealthier populations, even small additions of renewable energy generation can make a significant contribution toward providing access to modern energy services (Lloyd & Subbarao, 2009). A study by World Bank researchers found that "[d]ecentralized renewables are competitive mostly in remote and rural areas, while grid connected supply dominates denser areas where the majority of households reside" (Deichmann *et al.*, 2010: 1). Given the extremely high rates of household poverty and tight constraints on national budgets, LIC governments should try to leverage funds for energy development from international and regional development banks, international development agencies, non-governmental organisations and private corporations.

2.2.2 Transport

As in the case of energy, use of petroleum-driven transport is limited in LICs, with very low rates of motor vehicle prevalence per capita (see section 1.2.2). Nevertheless, there are some short-term demand reduction measures that can help to alleviate fuel shortages. In the longer term, LICs face a great challenge in terms of improving mobility of people and goods in an affordable manner without becoming dependent on increasingly scarce and costly oil.

Short-term strategies

PREPARE AND IMPLEMENT FUEL CONSERVATION AND EFFICIENCY MEASURES IN THE TRANSPORT SECTOR.

A government-sponsored information campaign can inform passenger vehicle and truck drivers about **eco-driving** techniques that can potentially result in fuel savings of up to about 5 per cent (IEA, 2005). Ways in which drivers can improve fuel efficiency include: appropriate use of gears; curtailment of unnecessary idling; reduced use of air-conditioning; driving with windows closed; and avoidance of excessive acceleration and braking (Vanderschuren *et al.*, 2008: 25). Another source of increased fuel efficiency, particularly relevant in LICs, is improved **vehicle maintenance**, which includes correct tuning of the engine, maintaining the correct tyre pressures, regular replacement of air filters, and use of appropriate motor oil (Vanderschuren *et al.*, 2008: 25). For the most part, these measures do not require large expenditure outlays on the part of drivers, and are therefore particularly suited to a low-income context.

Improved **traffic management** systems in LIC cities, where a considerable amount of fuel is wasted in vehicles idling in traffic jams,[13] could help to conserve scarce fuel supplies. Reducing road speed limits on highways can lead to fuel savings, and has been implemented by numerous countries in the past (IEA, 2005). Measures such as promoting **car-pooling** and **telecommuting** (i.e. working from home using the Internet) have less applicability in LICs relative to wealthier countries, since there are fewer people in suitable white-collar service industries and only sparse availability of adequate Internet connectivity.

12 A critical variable for evaluating and comparing energy sources is the energy return on investment (EROI) ratio, which is discussed at the end of section 2.4.1.

13 For example, Jeon *et al.* (2006: 181) report serious traffic congestion in Accra, the capital city of Ghana, which at the time was a low income country.

Long-term strategies

INVEST IN ENERGY-EFFICIENT AND ELECTRIFIED TRANSPORT INFRASTRUCTURE TO REDUCE OIL DEPENDENCE.

Most LICs are characterised by a widespread lack of access to adequate motorised transport services, both private and public.[14] This is mostly because the majority of households are too poor to afford motor vehicles (which are quintessentially middle class consumption goods), while governments are financially constrained in their ability to provide public transport infrastructure, and citizens are frequently too poor to afford transit fares. As a result, the majority of citizens in many LICs typically rely on non-motorised transport (NMT), including walking, animal-powered transport and cycling. Of course, given the high proportion of the population typically living in rural areas (often engaged in subsistence agriculture), the need for daily mobility is limited relative to more urbanised societies. Therefore, there is limited scope in LICs for reducing oil use and dependency by replacing current fleets with more **fuel efficient vehicles**, simply because the existing numbers of motor vehicles are so small.

Possibly the most cost-effective and energy efficient strategy for improving personal mobility in LICs is the promotion of **bicycles**. For example, Brown (2009: 152) states that "[t]he surge to 430 million bicycle owners in China since 1978 has provided the greatest increase in mobility in history." Governments can support bicycle purchases through subsidies (e.g. rather than subsidising petrol), the introduction of bicycle sharing schemes (although theft may be an inhibitor), and ideally supporting local bicycle manufacturing industries. Furthermore, bicycle use can be promoted through the creation of bicycle lanes and pathways in cities.

As LIC societies become wealthier as a result of economic growth and development, demand for personal mobility will grow, and more households will be able to afford to purchase motor vehicles (cars and motorcycles) as their incomes rise. Because of income constraints, it is likely that most of these vehicles will be of a smaller, cheaper variety – and these are usually amongst the most fuel efficient vehicles, which is a positive factor in the face of future oil shocks and fuel scarcity. It would be even better if households acquiring vehicles for the first time purchased vehicles powered by **alternative fuels and propulsion mechanisms**, such as hybrid-electric vehicles (HEVs), battery-electric vehicles (BEVs) and compressed natural gas (CNG) vehicles. CNG vehicles may become a relatively more affordable option in those LICs that have recently discovered significant gas deposits (Mozambique, Tanzania and Madagascar) or those that import gas (Tajikistan and Kyrgyz Republic) (see section 2.2.1). However, most of the other alternative-fuel vehicles that are currently on the market are prohibitively expensive for all but the richest households in LICs. Affordability is also likely to constrain the ability of LIC governments to afford new, energy-efficient public transport vehicles (such as buses and trains) and airplanes.

The best strategy for promoting sustainable transport in the long run, however, would be for LIC governments to invest in the most energy-efficient and least oil dependent forms of **mass public transport**. Grid-connected electric vehicles (GCVs), including heavy and light rail trains, trolley buses and trams, are the most energy efficient form of motorised transport and do not rely on oil (Gilbert & Perl, 2008). However, GCVs require large capital outlays both to build the transport infrastructure, as well as supporting investments in electricity generation. Nevertheless, it would be preferable from a long-term perspective if LIC governments discouraged the purchase of private vehicles (for instance by imposing taxes) and rather subsidised public transport. Given their low rates of motor vehicle penetration, LICs have an opportunity to leap-frog the inefficient proliferation of private vehicles that characterises wealthier countries, and instead pursue a transport development path centred on efficient and more sustainable transport systems powered by renewable energy.

2.2.3 Agriculture and food

As shown in section 1.2.1, agriculture in most LICs is largely subsistence and involves a large percentage of the working population. Subsistence agricultural production by small-scale farmers in LICs is typically not mechanised and the bulk of produce is consumed on site; therefore there is minimal direct use of oil, although some farmers may use oil-based pesticides. The main threat posed by oil price shocks to subsistence farmers depends on the extent to which they use chemical fertilizers, whose prices tend to be closely related to oil prices (Brown, 2008). Commercial farming in LICs is mostly geared towards export markets, since there is so little domestic purchasing power. Many African countries, for example, rely heavily on cash crops (e.g. cocoa in Ivory Coast; coffee in Ethiopia and Uganda[15]). Commercial agriculture is much more dependent on oil than subsistence agriculture, particularly in terms of transporting products to ports for export. The challenges for developing countries are to enhance food security in the short- to medium-term, and to promote sustainable agricultural practices and food sovereignty in the long-term.[16]

Short-term strategies

IMPROVE RESILIENCE OF FOOD PRODUCTION AND DISTRIBUTION SYSTEM TO OIL PRICE AND SUPPLY SHOCKS.

An important means of enhancing short-term food security is to maintain adequate food stocks, which can be drawn upon in the event of shocks to local food production or rapid increases in imported food prices. Grain storage is particularly important, since grains form the main staple diet in most LIC societies. Although there is a cost associated with building and maintaining food storage facilities, these costs need to be weighed against the potential for socioeconomic damage that can result from severe food shortages. However, the great challenge of food security in LICs is highlighted by the fact that the vast majority of these nations rely to some degree or other on food aid from donor countries and multilateral organisations (WFP, 2012). Seven of the top eight food aid recipient countries in 2011 were LICs, together accounting for 45% of total food aid deliveries: Ethiopia (19%), Kenya (7%), Sudan (5%), Mozambique (4%), Somalia (4%), Afghanistan (3%) and Democratic Republic of Congo (3%). Every LIC in Sub-Saharan Africa received at least some food aid, and this region received 62% of all food aid delivered in 2011 (WFP, 2012: 30). Unfortunately for LICs, the economic impacts of oil shocks on developed countries could mean that less food aid is forthcoming during and immediately after oil price spikes. Donor countries' foreign aid budgets are often fixed well in advance in monetary terms, so that when food prices spike, recipient countries can simply afford to buy less food with the aid money they receive (Brown, 2012). According to the World Food Programme (WFP, 2012), global food aid deliveries in 2011 were the lowest since 1990, despite a substantial rise in the number of people classified as hungry in recent years. Since many LICs are already struggling to feed their populations, it is difficult to see how they will be able to afford to purchase and maintain significant food stocks to cope with emergencies. In some countries, however, this may be more of a political than an economic issue.

In addition to accumulating food stocks, another option is for countries to invest in **regional food security funds**. These funds pool the resources of a number of nations, and pay out amounts to member countries which suffer from food security crises. For example, following the FAO's Regional Conference for Africa in April 2012, which included representatives of 45 African nations (mostly LICs), an African Solidarity Trust Fund was created to support food security on the continent (FAO, 2012b, 2012c).

In times of acute fuel shortages, sufficient amounts of **fuel** should be **prioritised** for agricultural production (to the extent that it is needed by farmers for local food production) and distribution of food products, including food aid received from foreign countries. Similarly, during oil price spikes there is a case to be made for short-term **fuel subsidies** for those farmers who rely on diesel fuel to produce essential foodstuffs, even though industrialised commercial agriculture is relatively rare in LICs.

14 For example, Jeon *et al.* (2006: 180) noted that Ghana, an LIC at the time, had a road transport system suffering from "deplorable road conditions, poor vehicular maintenance, and poor law enforcement", and the country did not have an effective public transport system.

15 http://en.wikipedia.org/wiki/Coffee#World_production

16 Food sovereignty has been defined as "the right of each nation to maintain and develop their own capacity to produce foods that are crucial to national and community food security, respecting cultural diversity and diversity of production methods" (Pimbert, 2008: 43). Sustainable agricultural systems may be defined as those that efficiently utilise environmental goods and services whilst preserving natural, human, social, physical and financial capital (Hine et al., 2008: 6).

Long-term strategies

SYSTEMATICALLY REDUCE AGRICULTURE SECTOR'S RELIANCE ON OIL AND ENHANCE FOOD SOVEREIGNTY.

There is a clear need in LICs for increased **investment** in agriculture in order to boost economic growth and sustainable development, and to reduce poverty and inequality (FAO, 2012a). In LICs, as mentioned, there is generally comparatively little reliance on oil in the agriculture sector. In the subsistence sector especially, therefore, the appropriate long-term strategy is to develop agriculture in a way that does not become dependent on oil products – in other words, to circumvent the form of agricultural industrialisation that has taken place in more industrialised countries, which has been highly fossil fuel-intensive. Where and if/when mechanisation does become affordable (and desirable) as LICs develop, consideration should be given to alternative fuel and power sources for farm equipment, such as biodiesel and even electric-powered tractors. The commercial agriculture sector in LICs, which is relatively more dependent on oil, will have to adjust in the long run to rising oil prices and growing scarcity of fuel. **Diversification** of agricultural production, aiming at greater self-sufficiency and food sovereignty, would help to boost resilience and reduce the risks associated with reliance on just a few cash crops.

A key mitigation and planning strategy to avoid oil dependence is to adopt **agroecological farming** methods, whose goal is to apply "ecological concepts and principles to the design, development and management of sustainable agricultural systems" (Pfeiffer, 2006: 59). Agroecological farming involves "enhancing the habitat so that it promotes healthy plant growth, stresses pests, and encourages beneficial organisms while using labour and local resources more efficiently" (Altieri, 2009: 109). Agroecological farming emphasizes the avoidance of fossil fuel inputs as far as possible. This strategy will require state support for training small-scale farmers in advanced agroecological farming methods so as to boost yields sustainably. Also important is the preservation and dissemination of local indigenous knowledge about traditional farming techniques, which typically do not depend on oil-based inputs, as well as seeds of locally adapted crop varieties. The formation of farming **cooperatives** could be a useful way of mobilising scarce financial resources for investments that raise the productivity of land sustainably.

A second way of structurally avoiding oil dependence as the agriculture and food system develops in LICs is to take steps to preserve the **localised** character of food production (as in subsistence farming), or to **relocalise the food system** in areas where there are longer distances between the points of food production and consumption (e.g. in urban settlements). To a large extent, this strategy of minimising "food miles" must work hand-in-hand with a sustainable approach to the development of human settlements (see section 2.2.6 below). One way to do this is to promote **urban agriculture**, for example by setting aside tracts of land in cities for farming allotments. Urban agriculture became an effective adaptive survival strategy in Zimbabwe following the collapse of its commercial agriculture sector in the early 2000s, and provides an important channel for intergenerational transfer of farming knowledge and skills as the population urbanises (Brasier, 2012; Ngena, 2012). However, urban agriculture needs to be properly managed to ensure equity in access to land and the sustainability of farming practices, for example in terms of the impact on soils and water courses. Under a programme supported by the FAO, market gardens have been developed in several cities in the Democratic Republic of Congo; 65% of the capital city Kinshasa's vegetable needs are met from urban gardens (Brown, 2010: 177). Urban agriculture has been an effective means of addressing poverty in several major cities in African LICs, including Addis Ababa, Ethiopia, and Kampala, Uganda (Thornton *et al*., 2010: 614).

In recent years some LICs – including Cambodia, Ethiopia, Liberia, Madagascar, Mozambique and Zambia – have succumbed to the temptation to sell or lease large tracts of arable land to foreign companies or governments, in a process that has come to be termed "land grabs" (World Bank, 2010; Brown, 2012). While such leases or sales of land bring in foreign exchange revenue in the short term, in the long run they could have serious adverse implications for domestic food security. It would be particularly ironic and unfortunate if LICs were to trade arable land for the ability to import oil, as this would lock these countries into a cycle of dependency and vulnerability to oil shocks and rising food prices.

2.2.4. Macro-economy

As discussed in Part 1, oil price shocks affect many aspects of national economies at the macroeconomic level. Therefore policy-makers should incorporate oil shock mitigation strategies into their macroeconomic policy frameworks. This will allow greater short-term flexibility and therefore resilience, and also help to steer the economy in a more sustainable direction for the long term.

Short-term strategies

INSULATE THE MACRO-ECONOMY AGAINST EXCESSIVE OIL PRICE VOLATILITY.

The main tool for boosting near-term resilience to oil price shocks is to build up **foreign exchange reserves**, which can be drawn upon in the event of a severe (but transitory) oil price spike so that the country can continue to import fuel supplies. However, most LICs have very limited foreign exchange reserves (see section 1.2.1) and many competing demands on them, as these countries rely on a wide range of imports from food products and medicines to machinery. In their efforts to boost foreign exchange earnings, such as by promoting rapid increases in commodity exports, policy-makers should seek to avoid unsustainable practices that have adverse social and environmental consequences. LICs should certainly refrain from borrowing to finance increased oil costs, as this will only exacerbate macroeconomic problems in the longer run (see Bacon, 2005: 2). Reliance on foreign aid is also risky, as sources of aid might become scarcer when donor countries are also experiencing the economic hardships that are generally associated with oil shocks. **Hedging** by buying and selling in the oil markets is similarly risky given the high degree of uncertainty that characterised today's tight oil markets. The administrative capacity to implement hedging is probably lacking in LICs and could be very costly if badly managed (Bacon, 2005). Therefore, while LICs should attempt to create at least a modest foreign exchange buffer, they should in general focus on long-term strategies to boost macroeconomic resilience to oil shocks.

Long-term strategies

PLAN TO DECOUPLE ECONOMIC DEVELOPMENT FROM OIL CONSUMPTION.

In the Introduction, it was shown that conventional oil production appears to have peaked around 2008, and that net world oil exports have been on a declining trend since 2005, while oil prices have been on an upward trend. The likelihood that these trends will persist means that developing countries need to plan their long-term economic development paths on the assumption that oil will become increasingly scarce and expensive. This means that the historical linkage between economic development and rising oil consumption needs to be severed; in other words, there needs to be a **decoupling** of economic development from oil consumption.[17] In practice, many of the measures required to implement decoupling have been discussed in the preceding sections on energy, transport and agriculture; the point here is that decoupling should become an over-arching goal of macroeconomic policy and planning.

Fiscal policy, including revenue collection, spending priorities and borrowing, is one of the main policy domains that governments can employ in order to influence the long-term development path followed by their countries. It is critical that fiscal policy is conducted in a sustainable manner, i.e. without resorting to continual foreign and domestic borrowing to finance large budget deficits. For example, many LICs accumulated large debt burdens in the early 1970s as international banks conducted aggressive lending programmes and interest rates were low. However, when global interest rates rose sharply in response to the second oil shock in 1979, many poorer economies fell into debt traps that stifled their growth and development for many years to come by funnelling scarce funds from investment into debt service payments. Unfortunately, the economic impacts of oil price shocks tend to add pressure on governments to increase welfare spending, but simultaneously curb tax revenues by slowing the rate of economic growth. Resorting to increased borrowing in the short run would be self-defeating in the longer run since the oil-induced economic shocks could persist and recur. Thus in order to avoid snow-balling budget deficits and an increasing borrowing requirement, which over time could take a country dangerously towards a debt trap, finance authorities should aim to bring spending in line with tax revenues in the long term. In addition, sufficient space should ideally be created in budgets to allow governments to respond flexibly to exogenous shocks. To the extent that LIC governments are able to allocate expenditure to long-term infrastructure, it is vital that these scarce funds be used in ways that reduce reliance on imported oil, not increase it. Thus expenditure on upgrading and extending road networks should in general give way to spending on railways and other mass transit systems.

Monetary policy authorities face enormous challenges in an age of increasing oil scarcity and price shocks. Authorities should recognise that a certain amount of inflation is unavoidable following an oil price spike, but that severe spikes are often short-lived. Central banks should consider refraining from rapid interest rate hikes in response to transitory oil price spikes, as such rate adjustments may be permanently damaging to local businesses and highly indebted households. A moderate rate of inflation can actually help a country to adjust by allowing relative prices to change, and can be less damaging than deflation, which can lead to a sharp decline in economic activity (Douthwaite, 2010). However, LICs should also guard against excessive rates of price inflation that could, if accommodated by loose monetary policy, run away into hyperinflation. As amply demonstrated in Zimbabwe in the 2000s, hyperinflation is amongst the most catastrophic of macroeconomic conditions: when the public loses confidence in the value of money, economic activity grinds to a halt.

Industrialisation as pursued by almost all countries in the past has been tied to increasing consumption of energy in general and oil in particular. However, to mitigate future oil shocks and oil scarcity, **industrial policy** in LICs should chart a new course towards increasing oil import independence. Thus LIC governments should look for ways to stimulate those sectors that are labour intensive rather than energy and capital intensive. In LICs, there is a long and difficult road ahead to transform these economies from excessive reliance on commodity exports to more diversified and self-reliant sectoral mixes. This task will be made much more difficult by the anticipated higher energy prices compared to those that prevailed in the 20th century and which fuelled rapid growth in many of the world's countries. Adequate investment in human resource development (education, training and health) is essential in order to lay the foundation for economic diversification.

A world characterised by growing oil scarcity may demand a reorientation of **trade policy** away from export-led growth paths towards greater economic localisation and self-sufficiency. Rubin (2009) argues that rising oil prices following the peak and decline in world oil production will act in a similar manner to trade tariffs, altering the cost and incentive structure facing both exporters and importers to favour more localised trade. Many LICs are heavily dependent on just a few commodity export products – often those that are high in bulk but relatively low in value per weight. This presents a particular vulnerability to oil price rises, and should be mitigated through policies that foster economic diversification. For example, the lucrative fresh vegetable export industry in Kenya is wholly dependent on air freight to European customers, and is highly exposed to oil price spikes which could render this industry uneconomic.

2.2.5 Society

Given the wide ranging socioeconomic impacts of oil shocks, particularly in the LICs that have high rates of poverty and in some instances also income inequality, it is vital that strategies are formulated to protect vulnerable members of society and to ward against social strife and instability. As the African Development Bank notes, "[c]oping mechanisms depend on country-specific circumstances, especially the country's ability to cushion the effects of high oil prices on vulnerable groups" (AfDB, 2009: 166). Nevertheless, a set of generic mitigation strategies can be identified, which can be tailored to the specific needs and circumstances of individual countries.

17 **The United Nations Environment Programme (UNEP) report "Decoupling Natural Resource use and Environmental Impacts from Economic Growth" explains the concept of decoupling in detail (Fischer-Kowalski & Swilling, 2011).**

Short-term strategies

MAINTAIN SOCIAL COHESION IN THE FACE OF FUEL PRICE SPIKES AND/OR SHORTAGES.

As discussed in previous sections, sudden and pronounced spikes in the price of crude oil or restrictions on the quantity of available fuel can have harsh economic consequences with severe social welfare impacts. Under these circumstances, people whose lives are disrupted may take to the streets in protest, undermining social cohesion and stability. Authorities should have in place plans and policies that can be introduced at short notice in emergency situations (see IEA, 2005). Scarce fuel supplies will inevitably be **rationed** among the population, but this can be done in two basic ways: either through higher prices, which mean that people and businesses will consume amounts of fuel according to how much they can afford; or through state-directed rationing schemes which use some administrative mechanism to allocate fuel to consumers. Price rationing has the advantage of not requiring any complex administrative functions, but the downside is that the poor suffer the most and access to fuel can be highly uneven, potentially triggering social tensions. In LICs, prevailing fuel prices that are high relative to meagre incomes already act as an effective rationing mechanism by making petroleum fuels largely unaffordable for the majority of the population. Comparatively few households can afford to purchase private motor vehicles, while the majority of the large farming population cannot afford tractors. By way of illustration, in Mozambique petrol (used largely in private vehicles) accounts for just 15% of all petroleum product consumption, while LPG and paraffin account for 2% and 3%, respectively (IEA, 2013b). Diesel fuel accounts for 75% of oil product consumption; of this three-quarters is consumed by transport and a fifth by industry. Therefore little in the way of fuel savings will be achieved through rationing petrol to owners of private vehicles, and supply rationing is very difficult to implement in the industrial and commercial transport sectors. Furthermore, rationing schemes are administratively costly and prone to corruption – especially where institutions are weak, as is often the case in LICs.

When LICs that use oil extensively for electricity generation (e.g. Cambodia, Benin, Eritrea and Haiti) are confronted by oil supply shortages or cannot afford to purchase their usual quantities of oil, they have little alternative but to ration power through rolling blackouts. The challenge for governments is to **prioritise power allocation** to essential services (such as hospitals) and refrigeration of perishable food supplies, even though this may mean extra hardship for residential users and lost production in manufacturing.

In view of the difficulties in implementing supply rationing, there may be a case to be made for **selective fuel subsidies** that are targeted at the most vulnerable sectors of society. For example, many low-income households in LICs rely on paraffin for cooking and lighting, and steep fuel price increases exacerbate energy poverty amongst poor households. Unfortunately, targeted subsidies are difficult to implement in practice (Bacon, 2005: 4) and are likely to become increasingly unaffordable for LIC governments. Schemes in which vouchers are given to poor households impose a heavy administrative burden and require efficient distribution systems that are difficult to achieve in LICs. An alternative to targeted fuel subsidies is direct **income support** to poor households, although this measure also faces implementation difficulties in countries with large unbanked populations, not to mention financial constraints in cash-strapped LICs.

Long-term strategies

PLAN SOCIOECONOMIC AND SPATIAL DEVELOPMENT SO AS TO REDUCE OIL DEPENDENCE.

Given their low rates of oil consumption, LIC governments have an opportunity to plan their countries' long-term development paths in a way that avoids increasing oil dependence. There are two main strategies in this regard. The first strategy is to focus on building **resilient local communities**. This can be aided through local economic development (LED) strategies and policies. LED involves partnerships between communities, businesses and local governments that aim to boost economic competitiveness and activity as well as job creation within defined geographical areas, drawing as far as possible upon locally available resources (see Rogerson & Rogerson, 2010: 466-467). LED can involve the provision of infrastructure and services by both urban and rural municipalities, with the aim of improving conditions so that local businesses can thrive. It can also be promoted by "government-supported micro-credit lending facilities" (Brown, 2009: 162). According to Rogerson and Rogerson (2010: 468), LED can bring social benefits such as empowering local communities, stimulating dialogue, and nurturing civil society by promoting transparency and accountability. Furthermore, by utilising local human and natural resources, LED strategies can boost the resilience of communities and small businesses, and help to create sustainable livelihoods.

However, LICs face constraints on the successful formulation and implementation of LED policies, such as "lack of government capacity, poor governance and limited information about local conditions on which to base sound policies" (Rodriguez-Pose & Tijmstra, 2007:528). Rodriguez and Tijmstra (2007: 516) conclude that "LED may not be relevant for the poorest and most remote parts of [sub-Saharan Africa], where existing conditions do not provide a strong enough base on which to build LED strategies". Nevertheless, despite the relatively recent interest in LED in sub-Saharan Africa and the multitude of challenges facing LED implementation, "several studies confirm that LED as an alternative development approach is taking root in much of Africa" (Rogerson & Rogerson, 2010: 473).

The second strategy for achieving oil independence is to plan **sustainable human settlements** that are not predicated on oil-based transportation systems. For a start, LIC governments should try to delay or deter rapid urbanisation (and the attendant formation of informal settlements on the peripheries of cities) by supporting rural development. A programme to uplift rural populations, for example through support of small-scale farmers in the form of access to credit, knowledge and training, can reduce the push factors that contribute to urbanisation. Shackleton, Shackleton and Cousins (2001) advocate the land-based strategies of arable farming, livestock husbandry, and consumption and trade in natural resources as potentially effective mechanisms for rural development and creation of sustainable livelihoods in the communal areas of rural South Africa, which is much like rural areas in other African countries. In cities, it is essential that LICs **integrate transportation and land use planning** in a way that mitigates long-term rising oil prices. Thus authorities should plan compact cities and avoid urban sprawl, which locks cities into excessive road transport dependence.

2.2.6 Summary and conclusions

We conclude this section on LICs by summarising the mitigation strategies, listing a number of obstacles and constraints facing their implementation, and highlighting the positive opportunities that can be exploited. A summary of the oil shock mitigation strategies, policies and measures proposed for LICs in the preceding sections is provided in Table 21 below. The main strategies can be encapsulated as follows:

- Boost resilience to oil price and supply shocks by holding adequate oil stocks, accumulating a buffer of foreign exchange reserves, and preparing emergency responses plans to allocate scarce fuel supplies to priority sectors.
- Plan development in a way that does not increase oil dependency, for example by investing in renewable energy and efficient transport systems, and ensuring that cities develop sustainably while rural areas are not neglected.

Table 2-1: Summary of oil shock mitigation strategies for LICs

SOCIOECONOMIC SUBSYSTEM	SHORT-TERM STRATEGIES, POLICIES & MEASURES	LONG-TERM STRATEGIES, POLICIES & MEASURES
Energy	Insulate the economy from excessive oil price volatility and physical supply shortages. ■ introduce a fuel price smoothing mechanism ■ phase out general fuel subsidies when oil prices are relatively low ■ possibly implement temporary, targeted fuel subsidies or income support for critical users during severe shocks ■ increase strategic fuel stocks ■ forge regional energy alliances with oil-importing and oil-exporting countries ■ subscribe to a regional petroleum fund	Reduce reliance on imported oil through energy conservation and development of substitutes. ■ promote energy efficiency across the board ■ phase out oil-fired power generation ■ invest in substitutes for imported oil, e.g. indigenous oil & gas, renewable energy (hydro, solar, wind, biomass & biogas, geothermal) ■ expand electricity grid infrastructure, especially in cities ■ promote use of solar cookers & energy-efficient wood stoves ■ encourage decentralised micro-generation in rural areas
Transport	Prepare and implement fuel conservation and efficiency measures in the transport sector. ■ information campaign to promote fuel conservation & efficiency through eco-driving and vehicle maintenance ■ improve traffic management, e.g. reduce road speed limits, improve traffic flows in cities to reduce vehicle idling	Invest in energy-efficient and electrified transport infrastructure to reduce oil dependence. ■ invest in public transport infrastructure, e.g. electrified railways, bus rapid transit systems ■ support non-motorised transport in urban areas ■ promote bicycle, electric bicycle & scooter manufacture & distribution ■ use 'feebate' system and government procurement to promote uptake of efficient & alternative-fuel vehicles
Agriculture & food	Improve resilience of food production and distribution systems to oil price & supply shocks. ■ possibly provide temporary diesel fuel subsidies for commercial farmers in planting & harvesting periods ■ ensure sufficient fuel allocation for food distribution ■ join a regional food security fund	■ enhance food sovereignty by diversifying food production ■ preserve indigenous knowledge of traditional, oil-independent farming methods and local seed varieties ■ support knowledge & training in agro-ecological farming methods ■ encourage urban agriculture, e.g. by allowing mixed use zoning, allocating space for community gardens and allotments
Macro-economy	Insulate the macro-economy against excessive oil price volatility. ■ boost foreign exchange reserves to cushion impact of oil price spikes ■ avoid foreign and national debt build-up ■ refrain from rapid interest rate hikes in response to transitory oil price spikes ■ maintain exchange rate flexibility to avoid rapid depletion of foreign exchange reserves	Plan to decouple economic development from oil consumption. ■ incorporate 'decoupling' principle in economic policy and planning frameworks ■ reduce government budget and trade deficits as far as possible ■ use fiscal measures (selective taxes & subsidies) to promote green economy sectors & skill development ■ promote economic localisation to structurally reduce transport needs through government procurement policies ■ invest in sustainable energy, transport and telecommunication infrastructure
Society	Maintain social cohesion in the face of fuel price spikes and/or shortages. ■ launch public awareness campaign to promote social cohesion ■ prioritise fuel allocation to critical sectors & emergency services ■ improve poverty alleviation measures, e.g. job creation initiatives	Plan socioeconomic and spatial development so as to reduce oil dependence. ■ build resilient communities through local economic development ■ foster rural development to slow the pace of urbanisation ■ plan sustainable human settlements, e.g. compact cities that are pedestrian and cyclist-friendly ■ avoid urban sprawl

Although there is a wide range of potential mitigation strategies, policies and measures, their implementation cannot be assumed to be straightforward. Numerous **obstacles and constraints** will need to be overcome, many of which are likely to be particularly severe in many LICs. Examples of such constraints are listed below, although each country will need to evaluate its own situation. Awareness of the obstacles can help policy-makers to refine their mitigation plans in order to maximise the chance of their success.

- **Social** constraints can include: cultural norms such as resistance to modern forms of technology and the social changes these tend to catalyse; ideological lock-in to conventional conceptions of industrialisation and development; behavioural–psychological issues such as expectations and aspirations of the population, for instance in terms of personal mobility and status attached to car ownership; and debilitating social conditions such as endemic crime, violence, and even civil wars, which will make the task of implementing coherent mitigation strategies extremely difficult.
- **Political** factors: lack of political will and effective leadership; dominance of other short-term concerns such as poverty alleviation; lack of strong democratic institutions that protect the most vulnerable sectors of society; vested or opposing interests, including possibly large multinational corporations.
- **Institutional and organisational** limitations: weak state capacity (especially in failed states), e.g. for planning and project management; lack of strong governance and the rule of law; corruption in public and private sectors; lack of access to reliable and timely information that is required for planning; 2 shortages of requisite education and skills (e.g. engineers, managers).[19]
- **Economic** constraints: lack of state financial resources and heavy debt burdens; lack of foreign exchange; dependence on foreign aid; reliance on commodity exports with volatile prices; lack of domestic manufacturing capacity, which increases reliance on imports; low purchasing power amongst the population, which limits uptake of new technologies; lack of alternative infrastructure such as electricity grids and communication systems; costliness of alternative energy technologies.
- **Environmental** constraints: water scarcity, which can be a limiting factor for production of various types of energy; scarcity of land and biomass resources, especially given the extent of food insecurity; degradation of soils from deforestation; intensifying impacts of climate change; costliness of and limited access to other key resources that are required for components of renewable energy technologies and electric vehicles, such as rare earth metals and lithium (Klare, 2012).

Despite all of risks posed by oil shocks and the potential obstacles to the development and implementation of effective mitigation strategies, it is important for governments to understand the positive **opportunities** that are presented by these circumstances. Above all, because LICs are at an early stage of their development they have the opportunity to avoid many of the pitfalls of the oil-dependent development path that has been pursued by more advanced economies. These pitfalls include lock-in to inefficient, oil-dependent infrastructures such as fleets of internal combustion engine vehicles and sprawling urban areas where mobility and accessibility rely almost entirely on private cars. By contrast, LICs ideally need to engage in 'technological leap-frogging' – skipping the oil-intensive phase of industrial development and adopting newer, more sustainable technologies and infrastructures from the outset. There are gains to be reaped through late-comer adoption of more sustainable technologies such as renewable energy and electrified mass transport systems.

18 The African Development Bank notes that "[m]ost African countries lack data on demand and supply by end use, price, cost, inventory movement, investment, and trade flows, on a timely and consistent basis" (AfDB, 2009: 181).

19 "Energy projects in developing countries are often hampered by the lack of trained and experienced local energy professionals", a condition exacerbated by the 'brain drain' phenomenon (Ebenhack & Martinez, 2009: 78).

2.3 Lower Middle Income Countries

This section presents oil shock mitigation strategies for lower middle income countries (LMICs), defined by the World Bank as those with gross national income (GNI) per capita of between $1,026 and $4,035 in 2011. The following five subsections deal with strategies, policies and measures in five subsystems of the national socioeconomic system, namely: energy, transport, agriculture, macro-economy and society. The sixth subsection provides a summary and discusses obstacles and constraints that may limit the implementation of the mitigation strategies.

CREDIT: AEAMD RENEWABLE ENERGY

Solar photovoltaic farm

CREDIT: WIKIPEDIA

Bus rapid transit in New Delhi, India

2.3.1 Energy

The effect of oil shocks on the energy system clearly depends on the extent of reliance on oil relative to other energy sources. Short-term response plans aim to provide an immediate buffer during episodes of oil price or supply shocks, while long-term strategies attempt to minimise a country's exposure to oil shocks by diversifying sources of energy supply and promoting efficient use of energy.

Short-term strategies

INSULATE THE ECONOMY FROM EXCESSIVE OIL PRICE VOLATILITY AND PHYSICAL SUPPLY SHORTAGES.

Whether it is governments or consumers who bear the short-term burden of oil price shocks depends on the **fuel pricing and subsidy** regime in operation in a particular country. If there is full pass-through of international oil prices to domestic fuel prices, then consumers will bear the risk burden associated with fuel price spikes. If, however, the government subsidises fuel prices, then it assumes a portion of the burden commensurate with the extent of the subsidies (Yépez-García & Dana, 2012: 4). In many countries, the risk burden is shared by both governments and consumers. Governments that decide to subsidise oil purchases can protect the economy and citizens from the short-term socioeconomic impacts of fuel price spikes, but this action likely carries a longer-term opportunity cost in terms of foregone spending on capital investment and socioeconomic services. If, as argued in the introduction appears likely, oil price spikes become more frequent and the trend continues to rise, then subsidies will become less and less affordable and will crowd out other necessary spending. As a result, it may be advisable for government to gradually phase out petroleum subsidies, using the politically easier opportunities of periods when international oil prices are falling (Bacon, 2005: 4).However, managing oil price volatility is a particular challenge in countries where the power sector relies heavily on oil, as frequent electricity price fluctuations can have a negative impact on business investment plans and competitiveness. Price risk management instruments such as hedging can be employed to manage short-term oil price volatility, although this tool will be less effective if there is an underlying secular trend in oil prices (Yépez-García & Dana, 2012: 5). In any event, "A critical first step for any country considering a commodity hedging strategy is careful risk assessment and evaluation of alternative hedging strategies" (Yépez-García & Dana, 2012: 6).

To mitigate the risk of physical oil supply shocks (i.e., fuel shortages), LMICs should consider creating (or if they have them, enlarging) **strategic oil reserves**. Oil from these reserves can be released if or when there are disruptions to the flow of oil imports (e.g. triggered by a geopolitical event in the country's suppliers) or during times of excessively high oil prices (which would effectively mean the government subsidising fuel purchases). Strategic oil stocks can be held by governments and/or commercial fuel companies. Oil storage capacity is especially important for those countries (such as the majority of SIDS and Central American countries) that depend heavily on oil for electricity generation, as extended oil supply shortages can result in economically crippling and socially disruptive power cuts. By way of example, India aims to conform to the IEA's recommended level of stocks equivalent to 90 days of net imports (IEA, 2013a).

A third strategy is for countries to **diversify the sources of oil supply** from oil exporting countries, to minimise the risk of, for example, a geopolitical event disrupting the flow of oil from one or more suppliers. This is especially important for LMICs that import heavily from OECs in politically unstable regions such as the Middle East. In addition, LMICs should where possible seek to form regional alliances with oil producing countries. They should also pursue regional energy cooperation with other oil-importing countries, for example by subscribing and contributing to a regional petroleum fund, and/or forming a regional power generation pool to diversify sources of power supply.

Long-term strategies

REDUCE RELIANCE ON IMPORTED OIL THROUGH ENERGY CONSERVATION & DEVELOPMENT OF SUBSTITUTES.

Conservation and efficiency

As energy consumption per capita is low in most LMICs, there is limited scope for oil conservation through curtailment of demand. However, there may be considerable scope for boosting both supply-side and demand-side efficiency in the use of oil products.

On the supply side, efficiency can be improved by modernising oil refineries. In countries that depend on oil for electricity generation, reduction of technical losses at the production stage can result in considerable fuel savings. Demand for electricity can be reduced through the introduction of "standards for widely-used industrial equipment and residential appliances; building codes; consumer education and demonstration programs; and energy management programs for industry, the buildings sector, and public utilities (Yépez-García & Dana, 2012: 8). Investments in energy efficiency are generally a cost-effective means of reducing oil consumption (Yépez-García & Dana, 2012). However, policy-makers need to be aware of the so-called "rebound effect", whereby improvements in energy efficiency can result in increased consumption of energy (both directly and embodied in goods) if they make energy services cheaper and hence raise disposable incomes (Berkhout *et al.*, 2000). The rebound effect is less of a concern if energy prices are rising, as this will act as a disincentive for consumers to increase their energy consumption.

Developing substitutes for imported oil

The most direct way to substitute for imported oil is to develop **indigenous oil resources**, if these exist. As of 2011, 15 out of the 37 LMICs in our sample produced at least some oil, although only 7 of these produced substantial amounts over 50 kbpd. Of these, Indonesia's production peaked in 2004 and output in Uzbekistan and Vietnam may have recently peaked. There is a possibility of substantial undiscovered oil reserves in the South China Sea, bordered by Vietnam, the Philippines, Thailand and China, but this area is already fraught with geopolitical tensions among these countries (Klare, 2012). The prospects for substantial new oil discoveries in other LMICs do not appear very good as their regions have generally been well explored (e.g. Central America) or are not known oil provinces (e.g. Sri Lanka, Lesotho, Swaziland and Zambia, and a number of Small Island Developing States). Costly investments in oil refining capacity are not advisable in countries that do not produce meaningful quantities of oil themselves. Given that refineries provide no security against crude oil supply and price shocks, the funds would be better spent on alternative energy investments. Furthermore, to be efficient and internationally cost competitive, refineries have to be on a very large scale (several hundred thousand barrels per day), which would be prohibitively costly for most LMICs – with the exception of large countries like India – and far in excess of their consumption requirements.

Natural gas is the closest substitute for oil, in that it can be used to power internal combustion engine vehicles (in the form of CNG), be converted into gas-to-liquid fuels, or burned for heating or power generation. CNG is already being used extensively in Pakistan and several major Indian cities. These countries plus Ukraine are among the top ten countries in the world in terms of number of CNG vehicles (NGVA, 2012). The IEA (2011c: 7) states that "[t]he global natural gas resource base is vast and widely dispersed geographically," but cautions that the commercial exploitation of these resources hinges on a mix of technological, economic and policy factors, and could take decades to deliver. Net oil-importing LMICs with proven natural gas reserves include Bolivia, India, Indonesia, Pakistan, Papua New Guinea, Ukraine and Vietnam, all of which produce oil as well (BP, 2012). In addition, Paraguay (63 tcf), Bolivia (48 tcf), India (63 tcf), Pakistan (51 tcf) and Ukraine (42 tcf) were amongst the LMICs estimated to have technically recoverable shale gas resources in a report commissioned by the US EIA (2011). The remaining LMICs have poor prospects for indigenous natural gas reserves. Natural gas can be imported via pipelines or LNG, but this requires costly investment in capital infrastructure. India is the only LMIC which imported LNG in 2011, according to BP's dataset (2012). Amongst LMICs, only Morocco (situated next to Algeria, a major gas exporter) and the former Soviet states of Armenia, Georgia, Moldova and Ukraine imported gas via pipeline in 2011 (BP, 2012). A disadvantage of natural gas is that its prices are usually positively correlated with oil prices in most regions, so utilisation of imported gas will not completely shield countries from the effects of oil price shocks.

Coal can potentially be substituted for oil in thermal electricity production and after conversion to CTL fuels. Net oil-importing LMICs with significant coal reserves include India, Indonesia, Mongolia, Pakistan, Ukraine and Vietnam (BP, 2012). Swaziland produces small amounts of coal, all of which are exported to South Africa. CTL production facilities require very costly capital investments that are probably beyond the reach of all but the largest economies. India's Tata Group has been exploring a possible joint venture with South African CTL leader Sasol Limited (Marais, 2011). However, India is a net coal importer and frequently experiences shortages of coal needed for electricity generation; these factors might thwart the development of CTL. China's switch to being a net coal importer in 2010 has had a major impact on the world coal market, and is likely to out-compete smaller economies for depleting coal reserves.

As in the case of LICs, for many LMICs the best prospects for developing sustainable substitutes for oil are likely to be found in indigenous **renewable energy** (RE) sources (biomass, liquid biofuels, biogas, hydropower, solar, wind and geothermal energy).

Biomass remains an important source of energy in many LMICs, which have yet to make a full transition to modern energy sources (see section 1.3.2). However, in these countries (e.g. Zambia, Senegal, Honduras, Guatemala, Paraguay and Sri Lanka), most of the biomass is not burned efficiently. More efficient woodstoves for household use, and wood pellets for industrial use, could help to meet energy needs more sustainably (REN21, 2012: 33). India, for example, has recently entered the wood pellet industry. In LMICs situated in the tropics, such as Central America and the Caribbean, sugarcane bagasse represents an important potential source of fuel for renewable electricity generation (Yépez-García & Dana, 2012).

Biogas produced from agricultural wastes, manures and sewage can be used for residential purposes (cooking and heating), or for small-scale industrial processes and for electricity generation. Biogas digesters are already used extensively in some LMICs, notably India, which has the world's second largest number of domestic biogas digesters (4.4 million in 2011), and Vietnam (REN21, 2012: 33). Biogas holds very good potential for replacing liquefied petroleum gas (LPG) in LMICs, particularly in rural areas. Biogas production technology is simple and efficient at both large and small scales, in both rural and urban settings, and biogas systems can be constructed and operated locally (Amigun *et al.*, 2008: 701-2). Capital costs represent the largest component of biogas costs, while operation and maintenance costs are relatively low and the feedstock is often free as it consists of various waste materials (Amigun *et al.*, 2008: 702). Transport costs are the second largest component of manufacturing costs, and therefore decentralised plant location close to feedstock sources (and final consumption) is important (Nolte, 2007). Biogas therefore presents a very good opportunity for sustainable energy supply on a modest, local scale.

Liquid biofuels, including ethanol and biodiesel, can be produced from a variety of crops and can substitute directly for oil in internal combustion engine vehicles. India was the leading biofuel producer among LMICs in 2011, but produced only 6 kbpd (BP, 2012). Indonesia is a significant producer of palm oil, which is used as a feedstock for biodiesel; however currently most of the product is exported to the European market. However, first-generation biofuels have several important disadvantages: they have relatively low EROI compared to oil, producing barely any positive net energy return in the case of corn-based ethanol (Murphy *et al.*, 2010); growing production of biofuels between 2004 and 2008 was identified as one of the primary factors contributing to a massive rise in global crop and food prices (Baier *et al.*, 2009), which resulted in the number of hungry persons in the world increasing to over one billion; production of biofuels often entails environmental problems such as soil degradation, excessive fresh water consumption and pollution; and if new lands are converted to biofuels production then net CO_2 emissions over the full life cycle might be substantially positive and therefore contribute to global warming (Pineiro *et al.*, 2009).

Hydroelectricity, derived from mostly large-scale installations at dams, is the world's foremost source of RE. Hydropower is common amongst LMICs, but there is potential for expansion. For example, water-rich Paraguay derives all of its electricity from hydropower. Vietnam added 1.9 GW of new capacity in 2011, raising its total capacity to 7.4 GW (REN21, 2012: 42). India has 3.3 GW of small-scale hydro capacity, which shows the promise of this form of RE for other countries.

Solar energy is an increasingly attractive option for water heating, rural cooking, and for electricity generation. Although use of solar energy is still very limited in LMICs, India is leading the way in many applications. For example, according to REN21 (2012: 54), "India added about 0.36 GWth (0.52 million m2) of solar heat capacity in 2011, for an estimated total of 3.5 GWth (5 million m2), driven by national policies, rising energy prices, and increased public awareness." Solar PV is still scarce in most LMICs, with the exception of India, whose cumulative installed capacity of solar PV grew to 427 MW in 2011, an increase of 165% over 2010 (BP, 2012). As PV module costs continue to fall with technological development and economies of scale in production, solar PV will become an increasingly competitive option for LMICs. Concentrated solar power (CSP) is currently one of the most expensive sources of electricity, although as the technology improves it may become within reach of LMICs. India commissioned its first CSP plant of 2.5 MW in 2011, and is also constructing a solar power tower of up to 10 MW capacity, slated for completion in 2013 (REN21, 2012: 51). Two of the big advantages of CSP is its ability to provide thermal storage (e.g. in molten salt) and thus dispatchability on demand, and the potential for it to be hybridised with other energy sources (REN21, 2012: 52).

Wind power, as noted earlier, is becoming increasingly competitive with traditional sources of electricity and is experiencing rapid growth in many parts of the world (see Figure 2-4). India is by far the leading LMIC in terms of installed wind power capacity with 16 GW by 2011, ranking it fifth in the world (BP, 2012). Wind power is still scarce in most LMICs, although this is beginning to change. For example, Honduras installed its first commercial wind turbines in 2011 (REN21, 2012: 57). Cape Verde accounted for the lion's share of new wind capacity in Africa in 2011, increasing its capacity from 2 MW to 27 MW (REN21, 2012: 57). This shows that wind power – particularly the off-shore variety – is a viable option in Small Island Developing States, many of which are currently highly dependent on oil for electricity generation. Given the intermittency of wind energy, countries erecting turbines will also need to invest in electricity grids and/or storage and back-up capacity.

Geothermal energy can be used to generate electricity or for heating. As of 2011, Philippines (1967 MW), Indonesia (1189 MW), El Salvador (204 MW), Nicaragua (88 MW), Guatemala (52 MW) and Papua New Guinea (56 MW) were the only LMICs with installed geothermal power capacity (BP, 2012). The Philippines and El Salvador are world leaders, as they generate nearly a quarter of their electricity from geothermal energy (Brown, 2008: 252). Indonesia could

Figure 2-4: Map of developing countries with installed wind power capacity

SOURCE: REN21 (2013)

theoretically meet all of its electricity needs from geothermal power (Brown, 2008: 253). According to the IEA's Technology Roadmap: Geothermal Heat and Power, "Deployment of low- and medium-temperature hydrothermal resources in deep aquifers will also grow quickly, reflecting wider availability and increasing interest in their use for both heat and power" (IEA, 2011b: 5).

Ocean energy technologies (including mechanisms to capture tidal, wave and ocean current energy) are still in their infancy, and thus far have been developed and deployed only by high income countries such as France, Spain, South Korea, the United Kingdom and Portugal (REN21, 2012: 45). LMICs are unlikely to be early adopters of these technologies because of their current high costs, but those countries with coastlines – and especially large tidal ranges – should nevertheless track developments in this promising area.

Each LMIC will need to evaluate the energy, economic, environmental and social costs and benefits of a range of alternatives to oil, based on local conditions. One of the critical factors in choosing energy alternatives will be the energy return on investment (EROI), which is discussed briefly in section 2.4.1.

Regional energy integration

A third long-term strategy, which is particularly relevant for countries that are highly dependent on oil but lacking in substantial domestic energy resources, is to forge closer regional integration with countries that have more diversified energy supplies. This allows "optimizing electricity supplies across the region, which improves efficiency and, owing to economies of scale, lowers generation costs" (Yépez-García & Dana, 2012: 8). It can also reduce the need for investment in electricity reserve requirements. The Southern African Power Pool, which includes LMICs Lesotho and Swaziland, is one example of such regional energy cooperation.

2.3.2 Transport

Near-term strategies for mitigating oil shocks in the transport sector involve implementing measures that conserve fuel while maintaining the current physical infrastructure of transport systems. Longer term strategies are aimed at changing the infrastructure to become less dependent on oil. Specific policies and measures are detailed below for each general strategy.

Short-term strategies

PREPARE AND IMPLEMENT RAPID FUEL DEMAND REDUCTION MEASURES IN THE TRANSPORT SECTOR.

Eco-driving techniques can potentially result in fuel savings of up to about 5 per cent (IEA, 2005). Ways in which drivers of passenger cars and trucks can improve fuel efficiency include: appropriate use of gears; curtailment of unnecessary idling; reduced use of air-conditioning; driving with windows closed; and avoidance of excessive acceleration and braking (Vanderschuren *et al*., 2008: 25). A government-sponsored information campaign can inform drivers about such techniques, and government employees can be given training. However, there is little authorities can do to enforce such behavioural change, although higher fuel prices will act as an incentive for their adoption.

A related means of increasing motor vehicle fuel efficiency is to ensure adequate **vehicle maintenance**, which includes correct tuning of the engine, maintaining the correct tyre pressures, regular replacement of air filters, and use of appropriate motor oil (Vanderschuren *et al*., 2008: 25). Again, the public can be informed about these measures, but they cannot be enforced. Unfortunately, motorists and companies may choose to curb expenditure on vehicle maintenance (especially servicing of vehicles) when fuel prices are high.

Improved **traffic management** systems in cities, where a considerable amount of fuel is wasted by vehicles idling in traffic, could help to conserve scarce fuel supplies. Measures include the use of traffic circles (roundabouts) and yield signs instead of traffic lights. Reducing road speed limits on highways can lead to substantial fuel savings, and has been implemented by numerous countries in the past with substantial success (IEA, 2005).

In LMIC cities with large numbers of commuters who use private motor vehicles, the promotion of **car-pooling**, for instance through information campaigns and the allocation of dedicated car-pool lanes on highways, can potentially yield large fuel savings (IEA, 2005). Nevertheless, the organisation of effective car-pooling in an LMIC context may have to rely on individuals, which is likely to limit its effectiveness. The promotion of **telecommuting** (i.e. working from home using the Internet) may have some applicability in LMICs that have well-established broadband Internet connectivity in major cities, although this would be limited to a restricted segment of the working population.

Fiscal instruments such as raising vehicle licence fees, road taxes and perhaps levying congestion charges in large cities could encourage private motor vehicle users to shift to other modes such as public transport. However, such measures are likely to be highly unpopular and also depend on there being sufficient spare capacity in the public transport system. **Selective driving bans** are a regulatory alternative to the use of fiscal incentives to reduce demand for fuel, but face similar obstacles.

The main advantage of these short-term strategies is that they can be very cost-effective ways of conserving scarce fuel supplies. The major limitation is the difficulty in enforcing several of the measures, which rely mainly on voluntary behavioural changes. The IEA (2005) stresses the importance of adequate pre-planning and preparation, so that the above measures can be implemented quickly in times of high fuel prices or fuel scarcity.

Long-term strategies

INVEST IN ENERGY-EFFICIENT AND ELECTRIFIED TRANSPORT INFRASTRUCTURE TO REDUCE OIL DEPENDENCE.

A simple way to reduce oil consumption over time is to encourage consumers and businesses to purchase more **fuel efficient motor vehicles**. Improvements in the design of vehicles, for example in terms of size, materials and engine configuration, can bring substantial fuel efficiency benefits (Lovins *et al*., 2005). In general, smaller vehicles are lighter and therefore more fuel efficient, since between 60% and 75% of fuel consumption is usually weight-dependent (Lovins *et al*., 2005: 47). Diesel fuel vehicles may be up to 30% more efficient than similar petrol vehicles (Vandershuren & Jobanputra, 2005), but the proportion of a barrel of crude oil that can be refined into diesel is limited and diesel is already the fuel of choice for freight vehicles. While rising fuel prices will encourage a shift towards efficient vehicles, the process can be accelerated through the implementation of higher taxes on less economical vehicles and rebates for efficient models (Kendall, 2008). Government procurement policies that favour efficient vehicles can also be effective. A third mechanism is to introduce fuel economy regulations for vehicle manufacturers, although this will only be effective in larger countries that have substantial vehicle manufacturing capacity. This strategy is particularly important in lower income countries that are experiencing rapid growth in vehicle sales off a low base: it is much better to start with an efficient vehicle fleet than to replace inefficient vehicles, as that process takes many years given the longevity of cars and trucks. Many LMICs already rely heavily on relatively fuel efficient motor vehicles, such as motorcycles, scooters and motorised rickshaws (see the India case study report as an example). This positive bias towards fuel efficiency, which has been driven in the past by affordability, should be further encouraged. Improved, modern designs can also yield substantial fuel efficiency gains in air and rail transport.

Even better than the above would be the encouragement (using similar policy instruments) of the adoption of vehicles powered by **alternative fuels and propulsion mechanisms**. Many such vehicles are entering the global vehicle market, including hybrid-electric vehicles (HEVs), battery-electric vehicles (BEVs), compressed air vehicles and hydrogen-powered vehicles. CNG vehicles are already popular in some LMICs (e.g. Pakistan and India), but are a less viable prospect in countries without ready access to natural gas. Of the alternative technologies for private vehicles, plug-in HEVs and BEVs hold the most promise at present (Gilbert & Perl, 2008), while hybrid truck models offer fuel savings while maintaining vehicle range. BEVs may be entirely independent of oil (except in the manufacturing stage) and have the advantage of using existing road networks. The main constraint on the uptake of these alternative vehicles, particularly in the LMIC context, is that they are still expensive compared to similar internal combustion engine vehicles (ICEVs). This may change as the scale of production of alternatives ramps up, although battery technology is still a significant limitation at present. Another important issue is that BEVs and plug-in hybrids will require a supporting infrastructure of recharging facilities, which requires a significant capital outlay either by local governments or by vehicle manufacturers.

The third and most important strategy for reducing long-term oil dependence is fostering **modal shifts**, for both passenger and freight transport. For passengers, the main modal shifts are from private vehicles to much more energy-efficient mass public transit (trains, trams and buses) and oil-independent non-motorised transport (NMT), such as cycling and walking. In a future of rising oil prices, air travel – which is amongst the least fuel efficient modes of travel – will increasingly need to give way to rail travel and telecommuting, unless there is a revolutionary breakthrough in aviation technology. Grid-connected electric vehicles (GCVs), including heavy and light rail trains, trolley buses and trams, are the most energy efficient form of motorised transport and do not require heavy and costly batteries as do BEVs (Gilbert & Perl, 2008), but they involve large capital outlays. Although public transport infrastructure is expensive, it must be recognised that large amounts of money are spent by many societies on relatively inefficient fleets of private vehicles. This applies to some LMICs, particularly those with rapidly growing economies and middle class populations. In the case of freight transport, the major modal shifts needed to reduce oil dependency are from trucks and air freight to railways and (where possible) ships. Modal shifts can be encouraged through taxes on private road vehicles and subsidised provision of safe, reliable public transport.

Despite their higher initial costs, Gilbert and Perl (2008) see electric-powered grid-connected vehicles as forming the backbone of future land-based transport systems. This is because: (1) electricity can be derived from a wide range of primary energy sources, including renewables; (2) transport systems based on electricity can easily adapt to changing primary energy sources, and thus avoid the need for changing infrastructure that is dependent on a particular energy source (e.g. oil or natural gas); and (3) the transport system's energy requirements will not constrain innovation in energy production systems. Given their relatively low rates of motor vehicle penetration, LMICs have an opportunity to leap-frog the inefficient proliferation of private vehicles that characterises wealthier countries, and opt instead for more efficient and sustainable transport systems powered by renewable energy.

2.3.3 Agriculture

The agriculture sector in many LMICs involves a mix of traditional, small-scale subsistence farming and a commercial sector producing products for both domestic consumption and in some cases for export (see, for example, the India case study). Therefore the strategies and policies that are recommended in this section for LMICs involve a combination of those discussed in the section 2.2.3 and 2.4.3 pertaining to LICs and UMICs, respectively. As discussed in Part 1, there are close links between food production and oil. On the one hand, oil products (mainly in the form of diesel fuel, pesticides and plastic packaging materials) are used intensively in commercial industrialised agriculture. On the other hand, rising oil prices have in recent years stimulated the production of biofuels made either directly from food crops or from feedstock grown on land that could otherwise produce food. These two linkages contribute to the fact that spikes in oil prices are usually followed in short order by spikes in food prices (see Figure 14). LMICs face the challenge of coping with short-term shocks to the food production and distribution system, as well as a longer-term challenge to reduce the oil dependency of the agriculture sector as global oil reserves deplete.

Short-term strategies

IMPROVE RESILIENCE OF FOOD PRODUCTION AND DISTRIBUTION SYSTEM TO OIL PRICE AND SUPPLY SHOCKS.

Global carry-over grain stocks have fallen in recent years to just 68 days of global consumption by the end of 2012, which is just above the lowest level recorded since 1960 (Larsen, 2013). Since 2000, annual world grain consumption has exceeded production in most years, including 2012. This situation has already led to food prices climbing to record highs, and the tightness in food markets raises the risk of further price spikes. When food prices rise rapidly or when crops fail due to extreme weather conditions, some food exporting countries restrict exports, reducing the amount available for importing countries (Brown, 2012). As a result of these conditions, as well as the close linkages between oil and food discussed earlier, an oil price shock can quickly lead to a spike in food prices, as occurred in 2008 and again in 2011.

One important strategy for LMICs to mitigate the risk of oil-related shocks to the agriculture and food system is to maintain adequate **food stocks**. In practice this refers mainly to grain inventories, as perishables cannot be stored and livestock numbers are restricted by available grazing and feed. Grain stocks can tide a country over in the event that either domestic production of grain and food products is interrupted by fuel supply shortages, or if food import prices suddenly become prohibitively expensive. Such stocks can obviously only be drawn upon on a short-term basis, and will have to be replenished when production recovers or grain import prices subside. For some LMICs, merely feeding their populations on a year-to-year basis is a massive challenge, as evidenced by the number of such countries that receive food aid (see WFP, 2012). Particularly noteworthy in this regard is the populous nation of Pakistan, which received 10% of global food aid transfers in 2011 (WFP, 2012). LMIC recipients of food aid in Latin America included Guatemala, Nicaragua, El Salvador and Honduras. Sri Lanka and Philippines were other notable food aid recipients in Asia. These countries will clearly find it very challenging to increase their grain reserves.

Another strategy for mitigating the impact of fuel price hikes on agricultural production is for governments to provide **fuel subsidies** for farmers, in recognition of the critical role that food production plays in human welfare and social stability. However, an alternative use of funds would be to subsidise food products instead, which would avoid the disincentive for farmers to economise on their use of fuel.

Physical disruptions to the supply of oil imports can have serious repercussions for farmers who use diesel and other petroleum products. Fuel shortages that occur during planting or harvesting periods could have devastating impacts on crop production. In such circumstances, governments should consider **prioritising fuel allocations** to agricultural production. Similarly, since urban populations rely on food that has been transported (often by truck) from farms, or imported even further distances from other countries, fuel allocations should also be prioritised for the distribution of food to consumers.

Long-term strategies

SYSTEMATICALLY REDUCE AGRICULTURE SECTOR'S RELIANCE ON OIL AND ENHANCE FOOD SOVEREIGNTY.

As global oil reserves continue to deplete and oil prices rise accordingly, LMICs will need to adopt strategies that systematically reduce their agriculture sectors' dependence on oil-based inputs. The chief way to achieve this is to implement policies that encourage farmers – particularly in the commercial sector – to adopt **agroecological farming** methods that expressly aim to minimise the use of fossil fuel inputs and rely as much as possible on locally available and natural material inputs. Draft animals can be used in place of tractors, bringing additional advantages of less compaction of soils and the generation of manure for fertilising; however, this would require additional land being set aside to grow animal feed. Alternatively, farmers can set aside part of their land to cultivate crops that can be used to produce biodiesel to fuel tractors and other machinery. Soil fertility can be improved through mixed cropping, such as the cultivation of food grains mixed with leguminous trees which fix nitrogen in the soil (Brown, 2010: 168). Such practices will reduce the need for fossil fuel-based fertilizers. Mixed cropping also reduces the need for petrochemical pesticides (Pfeiffer, 2006). The adoption of more efficient irrigation methods, such as drip-irrigation, can reduce the need for diesel to run water pumps (Brown, 2010: 170).

Unlike industrial agriculture, agroecological farming is more efficient on a smaller scale than a larger scale, and is inherently more labour intensive. It therefore has the potential to create numerous livelihood opportunities. States should support small-scale farmers with training in advanced agroecological farming methods so as to boost yields sustainably, while also taking steps to preserve and disseminate local indigenous knowledge about traditional farming, which typically does not rely on petroleum inputs. Financial support, such as low-interest credit, may be needed to support emerging farmers. In Cuba, the establishment of thousands of private cooperatives managed and owned by farm workers, helped a transition to more sustainable agriculture following a drastic fall in Cuba's oil imports after the collapse of the Soviet Union (Pfeiffer, 2006). Co-operatives reward individual members for their productivity and yet offer the benefits of economies of scale.

The process of urbanisation, LMICs in general are in the midst of a process of urbanisation as their economies develop (Crush & Frayne, 2011). The rapid growth of urban populations implies that an increasing number of households are located further from their food sources than before, when a greater proportion of households were engaged in subsistence farming. From our current vantage point, declining future oil supplies suggests that LMICs need to take steps to minimise the distances travelled by food products. **Localisation** implies production of a greater proportion of necessary foodstuffs occurs locally, while longer-distance trade is reserved mainly for luxury items (Heinberg & Bomford, 2009: 15). In order to promote food security, each area should produce regionally-adapted staple crops as far as possible. While the tide of urbanisation will likely continue in the foreseeable future, it is essential that local authorities plan sustainable human settlements that integrate food production into residential areas, for example by allowing mixed land-use zoning. According to Thornton *et al*. (2010: 613), "urban agriculture is increasingly being recognised not only as a survival strategy but also as a way to increase income and improve the overall quality of life." School gardens can serve a dual purpose: providing fresh local produce for pupils' lunches, and teaching pupils important skills for growing food (Brown, 2010: 177). Urban and peri-urban agriculture has been promoted in several Zambian cities, although still requires further institutional support, such as for access to land and for marketing of produce (Thornton *et al*., 2010: 622).

2.3.4 Macro-economy

LICs face numerous macroeconomic risks associated with international oil price shocks (see section 1.1). Thus macroeconomic policy frameworks should factor in both short-term and long-term strategies to strengthen economic resilience and contribute to sustainable economic development.

Short-term strategies

INSULATE THE MACRO-ECONOMY AGAINST EXCESSIVE OIL PRICE VOLATILITY.

Foreign exchange reserves provide an important buffer against sudden spikes in the price of oil imports, allowing a country to continue to import essential fuel supplies. Foreign reserves can be accumulated through increased exports and/or reduced imports. Both of these can in principle be stimulated by a weaker exchange rate, although this will come at the cost of higher imported price inflation (at least for a time), as well as domestic policies (such as higher interest rates) which curb consumer spending on imported goods. Borrowing from foreign financial institutions or governments to finance high oil import costs when prices spike is not sustainable (Bacon, 2005: 2). **Hedging** practices in oil markets is arguably too risky for LMICs in today's highly uncertain economic environment, and the administrative capacity to implement hedging may be overly burdensome (Bacon, 2005). Therefore, while LMICs should attempt to increase their foreign reserves in order to respond flexibly to emergency situations, they should in general focus on long-term strategies to boost macroeconomic resilience to oil shocks.

Long-term strategies

PLAN TO DECOUPLE ECONOMIC DEVELOPMENT FROM OIL CONSUMPTION.

The fundamental trends of global oil depletion and rising oil prices demand that developing countries plan their long-term economic development paths in a way that breaks the historical link between economic growth and rising oil consumption. This applies not only to the energy and transport systems, but to all sectors of the economy that rely on energy and transport – which is almost every economic sector and industry. Macroeconomic policies can help to bring about the kinds of restructuring that will make oil decoupling possible.

Fiscal policy should be conducted in a way that minimises budget deficits and avoids an accumulation of foreign and national debt. Such prudent fiscal management will allow greater flexibility to deal with the socioeconomic impacts of oil shocks, but could become increasingly difficult to achieve as oil shock impacts erode tax revenues and place extra demands on government spending. Increased public borrowing, except perhaps on a very short-term basis, would be unsustainable and would eventually crowd out needed investments in human capital and infrastructure. In fact, LMIC governments should attempt where possible to reduce their levels of borrowing and (especially external) debt when economic growth is relatively high and stable, so as to create fiscal flexibility to deal with oil shocks. Many LIC governments are engaged in significant capital expenditure programmes aimed at expanding basic energy, transport and communications infrastructures. **Infrastructure spending** by national, provincial and local governments should be planned in a way that supports the overall strategy of decoupling development from oil use. In practical terms this implies reduced spending on oil-related infrastructure such as roads and airports, and increased expenditure on the likes of electrified railways and information and communication technology (ICT) systems that structurally reduce the need for oil.

Since oil price shocks are likely to bring about stagflation in many economies (that is, simultaneous economic stagnation and rising prices), **monetary policy** authorities will have to tread a fine line between exacerbating contractionary tendencies in the economy on the one hand, and allowing damaging rates of price inflation on the other. A moderate rate of inflation – higher than what is conventionally considered to be prudent – can actually help a country's economy to adjust to structurally higher oil prices by allowing relative prices to change (Douthwaite, 2010). Inflation can also help a government to reduce the real value of its public debt burden, and can be less damaging than deflation, which can lead to a sharp decline in economic activity. However, LMICs do run the risk of losing control over inflation if it becomes too rapid, and must therefore guard against hyperinflationary policies such as excessive printing of money or monetisation of budget deficits.

Given the nascent stage of their industrialisation process, LMICs can potentially use **industrial policy** as a powerful way of guiding economic development onto a more sustainable path that does not increase dependency on imported oil. This is particularly relevant to the LMIC group as a whole, which is more energy intensive than the other income categories (see section 1.3.2). Selective taxes and subsidies can be used to boost sectors of the economy that are less dependent on oil, such as "green economy" sectors like renewable energy, energy efficiency, recycling and repair industries, manufacture of sustainable transport infrastructure, and so on. Industrial policy can also accelerate the structural shift from (especially heavy) industry to service sectors, including knowledge-intensive sectors. India is an example of an LMIC that has managed to grow its sophisticated service industries (such as those based on modern telecommunications) at a rapid rate. Such a shift is only possible if there is a solid foundation of education and training.

As transport costs rise and the reliability of freight transport is undermined by oil supply disruptions, international trade in physical goods (particularly high-bulk, low-value added items) will decline and supply chains will become shorter (Curtis, 2009). Effectively, higher transport costs will act as a tariff on imported goods. As a result, the process of globalisation (at least as it pertains to trade in physical goods), which has depended on cheap, reliable transport, could move into reverse (Curtis, 2009; Rubin, 2009). This calls for a re-orientation of trade policy from export orientation toward greater localisation and national self-sufficiency. LMICs that rely heavily on bulk commodity exports, including agricultural products and mineral ores, might face declining demand as a result of ballooning transport costs. Provided sufficient domestic energy is available, it may make sense for exporting countries to pursue beneficiation strategies so that they rather export higher-value, lower-weight finished goods.

2.3.5 Society

If the allocation of scarce fuel amongst consumers is left to markets, then the price mechanism together with distribution of income will ensure that richer households and more robust (typically, larger) businesses will be able to continue purchasing fuel, while poorer households and smaller businesses will have to curtail their consumption. This exacerbation of inequality in access to petroleum products could give rise to social discontent, tensions and even protests and riots. Hence LMIC governments should consider strategies to promote equity and maintain social cohesion, while in the long run finding ways of reducing their society's oil dependence.

Short-term strategies

MAINTAIN SOCIAL COHESION IN THE FACE OF FUEL PRICE SPIKES AND/OR SHORTAGES.

O ne way to address this risk is to introduce **fuel rationing schemes**. Rationing systems have been adopted in many countries in the past, both for oil and for other essential commodities. The most basic fuel rationing scheme involves booklets of coupons being issued to citizens on the basis of registered vehicle ownership, historical consumption patterns, and/or priority users (Hirsch *et al*., 2010: 88). Citizens would have to relinquish their coupons (e.g. denominated in litre units) every time they purchased petrol or diesel; retailers would pass on coupons to refiners; and refiners would transfer the coupons to the government. Such a rationing system would have to be complemented with domestic oil price and refined fuel price controls, else petrol and diesel prices would rise to market-clearing levels. A secondary market for fuel coupons would develop, so that citizens requiring (and being able to afford) more fuel could purchase ration coupons from those needing less. The main advantages of a rationing system are its fairness, the elimination of inefficient queuing, and the opportunity for government to allocate coupons to priority users such as emergency services and those with particular hardships or high fuel dependency. However, such simple systems have many drawbacks, including: high administrative costs and human capacity requirements; interest groups exerting pressure on government officials responsible for coupon allocation; possible forgery of coupons; greater complexity if companies and state institutions are included; economic inefficiencies associated with price controls and allocation; and a limitation of ration trading opportunities to local areas (Hirsch *et al*., 2010; Fleming, 2007: 25). Furthermore, the rationing of a commodity almost invariably leads to the emergence of a black market, i.e. illegal trade in the commodity at unregulated (possibly very high) prices, which may undermine the effectiveness of the rationing scheme.

If consumers are made aware of the factors contributing to fuel price rises – which are largely beyond the control of their governments – then public opposition and protests may be reduced. Thus **public awareness campaigns** can help to promote social cohesion in times of economic stress. For example, governments can use state media outlets such as radio and television, as well as the print media, to explain the fuel situation, what the state is doing to respond, and how citizens can contribute. In particular, transparency in the fuel pricing regime is essential in order to reduce the risk of consumer protests. The African Development Bank (AfDB, 2009: 64) notes that "transparency entails both making information widely available to the public and selecting measures that are easily verifiable."

Long-term strategies

PLAN SOCIOECONOMIC AND SPATIAL DEVELOPMENT SO AS TO REDUCE OIL DEPENDENCE.

As discussed in section 2.2.5, **local economic development** (LED) represents a strategy with growing relevance and popularity in the developing world as a means to boost local economies and livelihoods and build resilient communities in the face of global economic pressures. LED typically involves collaboration between local government, private sector enterprises and civil society organisations, with the role of the former being mainly to help create a favourable environment for business and job creation (Swinburn, 2006: 4). An LED strategy involves five stages (Swinburn, 2006: 4): (1) organising the effort by developing a management team and partnership network; (2) performing a local economy assessment to establish strengths and weaknesses; (3) creating an LED strategy; (4) implementing the LED strategy; and (5) reviewing the LED strategy. LED strategies may include "property development, place marketing for inward investment, small, medium and micro enterprise (SMME) development, investment facilitation, improving the local business investment climate, encouraging local business, institutional development, upgrading skills and training, investment in business sites and premises, and cluster upgrading" (Rogerson & Rogerson, 2010: 472). Crucially, infrastructure investments by local governments must be undertaken in a sustainable manner – for example by harnessing locally available renewable energy resources and building efficient public transport systems.

Many LMICs are undergoing a rapid process of urbanisation, driven in part by the industrialisation process, which absorbs increasing numbers of working age people into jobs in urban centres (Bhattacharya, 2002). Persistent poverty in rural areas provides a strong push factor, encouraging migrants to seek opportunities in burgeoning cities. Ironically, some scholars of global oil depletion see the urbanisation process slowing down or even reversing in the 21st century – at least in the heavily urbanised industrialised countries. For example, Heinberg (2006b) contends that "re-ruralisation will be the dominant social trend of the twenty-first century", mainly because declining availability of fossil fuels to power industrial agriculture will imply a need for a steady increase in the number of farm workers. For LMICs, this raises important questions about the extent to which rapid urbanisation at this point in their development is a good thing or not, and how best it can be managed. As the recent report *Future Proofing Cities* points out: "There is an important – but closing – window of opportunity for many cities to act now before they are locked into unsustainable and unsuitable development pathways" (Godfrey & Savage, 2012: ix). To help ensure that urban settlements unfold in a sustainable manner, it may make sense to try to slow down the rate of urbanisation by fostering rural development (Brown, 2009: 161). This may help to avoid a rapid influx of people that overwhelms city infrastructure, and buys some time for authorities in cities and towns to plan urban development in a way that avoids unsustainable dependence on oil. Compact cities are important in order to maximise the opportunities for non-motorised transport (walking and cycling) and because population densities have to reach a certain threshold in order to support effective public transport (Jeon *et al*., 2006: 184). For example, Colombia's experience "with the Transmilenio Project in Bogotá is demonstrating the feasibility of transforming a city from an auto-centred to a pedestrian-oriented city" (Jeon *et al*., 2006: 184). Mixed use zoning can be an effective way of reducing necessary transport distances for urban dwellers.

2.3.6 Summary and conclusions

We conclude this section on LMICs by summarising the mitigation strategies, listing a number of obstacles and constraints facing their implementation, and highlighting the positive opportunities for socioeconomic transformation. Table 2-2 contains a summary of the oil shock mitigation strategies, policies and measures proposed for LICs in the preceding sections. The main strategies can be encapsulated as follows:

- Boost resilience to oil price and supply shocks by holding adequate oil stocks, accumulating a buffer of foreign exchange reserves, and preparing emergency responses plans to allocate scarce fuel supplies to priority sectors.
- Plan development in all areas of the economy that reduces reliance on imported oil, for example by investing in indigenous and renewable energy and efficient transport systems, and ensuring that cities develop sustainably while rural areas are also developed.

Table 2-2: Summary of oil shock mitigation strategies for -LMICs

SUBSYSTEM	SHORT-TERM STRATEGIES, POLICIES & MEASURES	LONG-TERM STRATEGIES, POLICIES & MEASURES
Energy	Insulate the economy from excessive oil price volatility and physical supply shortages. ■ introduce fuel price smoothing mechanism ■ gradually phase out fuel subsidies, except possibly temporary, targeted subsidies for critical users ■ ensure adequate strategic fuel inventories ■ diversify sources of oil imports ■ forge regional energy alliances with oil-importing and oil-exporting countries ■ subscribe to a regional petroleum fund	Reduce reliance on imported oil through energy conservation and development of substitutes. ■ foster energy conservation & efficiency with appropriate incentives & regulations ■ phase out oil-fired power generation ■ boost development of energy substitutes, e.g. indigenous oil, gas, & renewable energy sources ■ expand electricity grids ■ promote decentralised micro-generation from renewable energy sources in rural areas ■ promote use of solar cookers & efficient wood stoves
Transport	Prepare and implement rapid fuel demand reduction measures in the transport sector. ■ introduce information campaign to promote fuel conservation & efficiency through eco-driving, good vehicle maintenance, car-pooling, flexible work schedules, telecommuting & Internet based shopping ■ improve traffic management (e.g. reduce road speed limits, improve traffic flows to minimise vehicle idling) ■ construct car-pool lanes in cities ■ levy congestion charges in city centres ■ implement selective driving bans in times of fuel shortage ■ encourage modal shifts by increasing private vehicle taxes & licence fees and subsidising public transport	Invest in energy-efficient and electrified transport infrastructure to reduce oil dependence. ■ regulate fuel economy standards for road vehicles ■ use 'feebate' system and government procurement to promote uptake of efficient & alternative-fuel vehicles ■ invest in cycle lanes & pedestrian walkways to support non-motorised transport in urban areas ■ invest in public transport infrastructure, e.g. electrified railways, trams, electric bus rapid transit ■ support bicycle & electric bicycle manufacture & distribution ■ curtail investment in roads & airports ■ implement 'user pays' principle for road upgrades
Agriculture & food	Improve resilience of food production and distribution systems to oil price & supply shocks. ■ possibly provide temporary diesel fuel subsidies for farmers in planting & harvesting periods ■ ensure sufficient fuel allocation for food distribution ■ join a regional food security fund	Systematically reduce agriculture sector's reliance on oil and enhance food security. ■ enhance food sovereignty by diversifying food production ■ preserve indigenous knowledge of traditional, oil-independent farming methods and local seed varieties ■ support knowledge & training in agro-ecological farming methods ■ encourage urban agriculture, e.g. by allowing mixed use zoning, allocating space for community gardens and allotments
Macro-economy	Insulate the macro-economy against excessive oil price volatility. ■ boost foreign exchange reserves to cushion impact of oil price spikes ■ avoid foreign and national debt accumulation ■ refrain from rapid interest rate hikes in response to transitory oil price spikes ■ maintain exchange rate flexibility to avoid rapid depletion of foreign exchange reserves	Plan to decouple economic development from oil consumption. ■ incorporate 'decoupling' principle in economic policy & planning frameworks ■ reduce government budget and trade deficits as far as possible ■ use fiscal measures (selective taxes & subsidies) to promote green economy sectors & skill development ■ promote economic localisation to structurally reduce transport needs ■ reallocate funds from airports & roads to railways & telecommunications ■ practice wage restraint, especially in the public sector, to avoid wage-price spirals
Society	Maintain social cohesion in the face of fuel price spikes and/or shortages. ■ launch public awareness campaign to promote social cohesion during oil shock episodes ■ implement fuel rationing schemes that prioritise allocation to critical sectors & emergency services ■ improve poverty alleviation measures, e.g. job creation initiatives ■ forge regional alliances to enhance regional resilience and cohesiveness	Plan socioeconomic and spatial development so as to reduce oil dependence. ■ build resilient communities through local economic development ■ foster rural development to slow the pace of urbanisation ■ plan sustainable human settlements, e.g. compact cities that are pedestrian- and cyclist-friendly ■ avoid urban sprawl

The formulation and implementation of mitigation strategies will face a variety of **obstacles and constraints**, whose severity will vary across different LMICs according to their special characteristics. Preparation of mitigation strategies at a country level should ideally include an assessment of the particular obstacles, so that policy-makers can tailor their plans in order to maximise the probability of their success. Some of the generic constraints include the following:

- **Social constraints**: cultural resistance to change; ideological lock-in to conventional conceptions of industrialisation and development; behavioural–psychological issues such as expectations and aspirations of the population, for instance in terms of personal mobility and the status attached to car ownership.
- **Political factors**: possible political instability; lack of political will and effective leadership; preoccupation with other short-term concerns such as poverty alleviation; lack of strong democratic institutions that protect the most vulnerable sectors of society; opposing vested interests.
- **Institutional and organisational** limitations: weak state capacity, e.g. for planning and project management; lack of strong democratic governance; corruption in public and private sectors; lack of access to reliable and timely information that is required for planning; shortages of requisite education and skills (e.g. engineers, managers).
- **Economic constraints**: constraints on state financial resources; public and foreign debt burdens; lack of foreign exchange; limited consumer ability to afford new technologies; lack of alternative infrastructure such as electricity grids and communication systems; costliness of alternative energy technologies; lack of high-tech industries.
- **Environmental constraints**: water scarcity, which can be a limiting factor for production of various types of energy; scarcity of land and biomass resources, especially given the extent of food insecurity; degradation of soils; deforestation; intensifying impacts of climate change; costliness of and limited access to other key material resources.

Nevertheless, the threat of oil shocks also brings **opportunities** for positive changes towards greater long-term sustainability. Since most LMICs are not yet very heavily invested in oil-based infrastructures (such as large vehicle and airline fleets), they can to some extent circumnavigate the highly oil-intensive development path taken by more advanced economies. LMICs have the chance to pursue 'technological leap-frogging', i.e. avoiding the oil-intensive phase of industrial development by investing directly in more sustainable technologies and infrastructures and benefiting from the late-comer advantages. In a study of 20 Latin American countries, for example, Rubio & Folchi (2012) found that leapfrogging can permit relatively rapid energy transitions, especially in smaller countries. One way to facilitate an energy transition away from oil is to plan city development in a more rational manner so that urban areas are not structurally dependent on oil-powered, individual modes of transport.

2.4 Upper Middle Income Countries

This section presents oil shock mitigation strategies for upper middle income countries (UMICs), defined by the World Bank as those with gross national income (GNI) per capita of between $4,036 and $12,475 in 2011. The following five subsections deal with strategies, policies and measures in five subsystems of the national socioeconomic system, namely: energy, transport, agriculture, macro-economy and society. The sixth subsection discusses obstacles and constraints that may limit the implementation of the mitigation strategies, while the final subsection provides a summary.

CREDIT: LIANE GREEFF

Wind farm in the Western Cape, South Africa

CREDIT: GAUTRAIN

Gautrain rapid railway, Gauteng Province, South Africa

2.4.1 Energy

Oil shocks impact most directly on the energy system, and require short-term mitigation responses that aim to minimise disturbances, and long-term strategies that aim to minimise a country's exposure to oil shocks through energy conservation and broadening the energy mix.

Short-term strategies

INSULATE THE ECONOMY FROM EXCESSIVE OIL PRICE VOLATILITY AND PHYSICAL SUPPLY SHORTAGES.

Governments can adopt various **fuel pricing** regimes in order to manage the short-term impacts of oil price volability. If there is full pass-through of international oil prices to domestic fuel prices, then consumers will bear the risk burden associated with fuel price spikes. If, however, the government (partially) subsidises fuel prices, then it assumes a portion of the burden commensurate with the extent of the subsidies (Yépez-García & Dana, 2012: 4). In many countries, the risk burden is shared by both governments and consumers. Governments that decide to subsidise oil purchases can protect the economy and citizens from the short-term socioeconomic impacts of fuel price spikes. However, if – as argued in the introduction – oil prices continue to trend upwards, then subsidies will become increasingly unaffordable and will crowd out other social spending and weigh heavily on the government's debt. Furthermore, even temporary subsidies for oil would further encourage and entrench dependence on oil and militate against the necessary long-term investments in alternatives (see below). Oil subsidies also run counter to climate change mitigation initiatives, which seek to reduce consumption of fossil fuels. On the other hand, raising fuel levies in advance of oil price spikes could provide some leeway for cushioning the impact of future oil shocks by allowing space for a reduction of the levy when prices are high, thus helping to stabilise price fluctuations. However, higher levies are likely to be highly unpopular and could face significant opposition. At the very least, the IEA (2005) recommends that authorities do not yield to any pressure by the public or lobby groups to reduce fuel taxes, as this would encourage continued petroleum dependence. A regulated fuel pricing mechanism can smooth out short-term fluctuations in oil prices, but this would require an oil stabilisation fund (to be drawn upon when prices are high and replenished when they are lower) and significant administrative capacity. Alternatively, price risk management instruments such as hedging can be employed to manage short-term oil price volatility (Yépez-García & Dana, 2012: 5). However, both stabilisation funds and hedging will be less effective if there is an underlying upward trend in oil prices as forecast by IMF and OECD researchers, amongst others (see Benes *et al*., 2012; Kumhof & Muir, 2012; Koske *et al*., 2013).

Strategic oil reserves, held in special storage depositories, may provide temporary relief in times of acute oil shortages. For example, during the Apartheid era when it faced economic sanctions, the South African government constructed a sizeable storage facility with a capacity of 45 million barrels – about three months' worth of current oil consumption. Turkey is the only UMIC that is a member of the International Energy Agency, which requires is members to hold oil stocks equivalent to 90 days of net imports. In recent years China has been building a Strategic Petroleum Reserve (SPR), which aims to have a capacity of about 310 million barrels by 2013 and 500 mb by 2020 (IEA, 2012c), representing on the order of 65 days' worth of net oil imports. In addition, by the end of 2011 China reportedly had approximately 220 mb of commercial oil storage capacity. Chile, which is a member of the OECD but not of the IEA, has total petroleum storage capacity of 22 mb, of which a third is crude oil and two-thirds is refined product storage (IEA, 2012d). Its storage capacity for diesel, which is used heavily for electricity generation as well as transport, is rather meagre at just 12 days of consumption. However, oil stocks are of limited usefulness in a context of declining world oil exports, relative to investments that reduce oil dependency.

Thirdly, UMICs should ensure they **diversify their sources of oil supply** from oil exporting countries, to minimise the risk of disruptions to the flow of oil from one or more suppliers. This is especially important for UMICs that import heavily from OECs in politically unstable regions such as the Middle East. For example, South Africa has reduced its reliance on Iranian oil considerably over the past years by sourcing larger amounts of crude from countries such as Angola and Nigeria. A strategy to help secure oil supplies that may be open to some UMICs, particularly the larger and wealthier countries, is to forge regional energy alliances with oil producing countries. For example, some Latin American states, such as Cuba, have managed to secure deals with Venezuela's previous president, Hugo Chavez, who provided subsidised oil to strategic partners. China and India have used their political and economic power to enter into bilateral agreements with oil producing countries to secure long-term access to oil imports. For most of the smaller UMICs, which have little of strategic value to offer in return, however, regional or bilateral alliances are less likely to materialise. Finally, UMICs of all sizes could attempt to form regional alliances with other oil-importing nations, such as subscribing and contributing to a regional petroleum fund or subscribing to an international Oil Depletion Protocol (see Box 1).

Box 1: An International Oil Depletion Protocol

Campbell (2006) and Heinberg (2006a) outline an Oil Depletion Protocol as a cooperative response to declining oil supplies (see Appendix B for the full Protocol). The Protocol in essence requires all oil importing nations to agree to reduce their annual oil imports by a percentage equal to the World Oil Depletion Rate, which has been estimated by Campbell (2006) as approximately 2.6 per cent per annum. In addition, oil producing nations would agree to reduce their rate of production by their National Depletion Rate. The result will effectively be a global rationing system, which is intended to help stabilise oil prices and avoid wars over remaining oil, and thereby ensure that economic and social conditions are more conducive to the crash programme of mitigation required to avoid the worst potential economic impacts. Heinberg (2006a) suggests that the Oil Depletion Protocol could operate along-side carbon emissions-based agreements such as a strengthened and extended Kyoto Protocol.

While the Oil Depletion Protocol has merits in theory, it would face similar obstacles to international adoption and implementation as have confounded climate treaty negotiations. In particular, there are likely to be conflicts between various groupings of countries, such as between developed and developing nations (the latter may argue that they have a right to a greater proportion of remaining oil reserves to compensate for their lower historical oil consumption), and between oil importing and oil exporting nations. The situation resembles a complex version of the Prisoner's Dilemma, in that the individually rational country strategies are likely to lead to a socially suboptimal outcome. The Protocol represents a mutually cooperative set of strategies that could significantly reduce the risks of serious economic shocks and geopolitical tensions. Even though it would likely be difficult to achieve in practice, it would be to all countries' benefit in the long run.

Long-term strategies

REDUCE RELIANCE ON IMPORTED OIL THROUGH ENERGY CONSERVATION & DEVELOPMENT OF SUBSTITUTES.

Conservation and efficiency

Energy conservation, through curtailment of demand and improved efficiency, represents a cost effective way of reducing the need for oil products. Since most oil used by UMICs is consumed by the transport sector, this is the area which offers the greatest savings (see section 2.4.2 below). In addition, there may be considerable scope for boosting both supply-side efficiency in the production of refined fuels (by modernising refineries) and in the demand-side use of oil products in non-transport sectors, such as power generation (e.g. via reduction of technical losses in thermal power plants). Overall demand for electricity can be reduced through the introduction of various regulations (e.g. minimum efficiency standards for appliances and machinery), public awareness campaigns (informing citizens about ways they can conserve power and therefore save money), and building codes (Yépez-García & Dana, 2012: 8). Regulations aimed at improving the insulation of buildings and incentives to encourage the installation of solar water heaters can bring about large energy savings in UMICs. However, policy-makers need to be aware of the so-called "rebound effect", whereby improvements in energy efficiency can result in increased consumption of energy (both directly and embodied in goods) if they make energy services cheaper and hence raise disposable incomes (Berkhout *et al*., 2000). The rebound effect is less of a concern if energy prices are rising, as this will act as a disincentive for consumers to increase their energy consumption. Country-specific studies are needed to identify the best opportunities for energy efficiency gains.

Energy substitutes

As mentioned in section 1.4.2, the majority of oil-importing UMICs have little or no **indigenous oil** production and negligible prospects of this changing in the future. In those UMICs that are notable oil producers, crude production is on a declining trajectory in Argentina, Malaysia and Suriname, such that these countries will apparently become increasingly dependent on oil imports. The rate of increase in Chinese oil production is slowing, and production might peak within a few years (Feng *et al*., 2008). By contrast, oil production is on a strongly rising trend in Brazil, putting it on course to become a net exporter later this decade. Cuba has reasonably good prospects of developing new oil fields. But while exploration for new oil fields is continuing in several countries, indigenous oil production is unlikely to shield the majority of UMICs from oil shocks in the longer term and they will have to utilise other energy resources.

Natural gas can substitute for oil for heating and thermal electricity generation purposes, and even in transport in the form of compressed natural gas and gas-to-liquid fuels. Natural gas is also used as a feedstock for petrochemical products, and in many such applications it can substitute for oil. Gas has considerable advantages in terms of high energy density (per unit of mass, but not by volume), and can be easily transported and stored, provided that the infrastructure is affordable. It is also cleaner burning than oil, with smaller CO_2 emissions per energy unit. Argentina, Brazil, China and Thailand are among the top ten countries in the world in terms of number of CNG vehicles (NGVA, 2012). The IEA (2011c) suggests that the world might be entering a "golden age" of gas as many countries around the world are moving to exploit gas resources. Net oil-importing UMICs with conventional natural gas reserves include Argentina, Brazil, Peru, Romania, China, Malaysia and Thailand (BP, 2012), although only Malaysia has large reserves and a significant scale of production compared to its overall energy consumption.

In recent years, increasing attention has been paid to **unconventional natural gas** resources, chief amongst which is shale gas. The exploitation of previously inaccessible gas trapped in shale basins in the United States by means of horizontal drilling and hydraulic fracturing technologies has led to a rapid increase in gas production and a considerable fall in prices. According to a report commissioned by the US Energy Information Administration (EIA, 2011: 1), four net oil-importing UMICs, namely China, Argentina, South Africa and Brazil, feature amongst the top twelve national shale gas resource endowments (which collectively represent 90% of the world total). Other UMICs with assessed shale gas resources included Chile and Uruguay (the scope of the study excluded much of the former Soviet Union and almost all of sub-Saharan Africa and south-east Asia). However, there are concerns about possible environmental and health side-effects associated with "fracking" (see e.g. Hughes, 2011; Howarth *et al*., 2011), which have led several countries to ban shale gas exploration. At present, shale gas exploration is in its infancy in China and South Africa, and it is likely to be several years at least before any gas is produced. Other countries, such as Botswana, are pursuing coal-bed methane, which is a form of natural gas associated with coal deposits. The most direct way that gas can substitute for oil-based transport fuels is through gas-to-liquid (GTL) fuels. South Africa is the only net oil-importing country with commercial GTL production capability. For those countries with substantial natural gas reserves – either conventional or unconventional – GTL presents an attractive strategic option to mitigate oil scarcity, although the capital costs are high, as are the carbon emissions compared to renewable energy alternatives.

Those UMICs that do not have substantial indigenous gas resources should consider options for importing gas, either through pipelines from neighbouring countries, or through LNG terminals if they have suitable coastal ports. The South American nations of Argentina, Brazil, Chile and Uruguay, together with the former socialist or Soviet Republics of Belarus, Bosnia & Herzegovina, Latvia, Lithuania, Macedonia, Romania and Serbia, all imported gas via pipelines in 2011 (BP, 2012). These two groups of countries benefit from long-standing regional pipeline networks. In addition, South Africa imports a modest quantity of gas through a relatively new pipeline from neighbouring Mozambique, which could be expanded in the future. Argentina, Brazil, Chile, Dominican Republic, Puerto Rico, Turkey, China and Thailand all imported LNG in 2011 (BP, 2012). The downside to importing natural gas is the high capital cost of constructing the pipeline or LNG infrastructure. These costs may be beyond the economic means of the smaller UMIC economies, and logistically impractical in those situated far from gas deposits (most notably small island states). The final consideration is that gas prices are for the most part fairly closely correlated to the oil price – the one exception being the US gas price in recent years. The IEA (2011c) expects increasing convergence in inter-regional gas markets and prices over the coming decades, meaning that individual gas-importing countries will increasingly pay world prices.

Coal can substitute for oil in some thermal uses (e.g. power generation) and can be converted into synthetic liquid fuels via CTL technology. Net oil-importing UMICs possessing coal reserves include China, South Africa, Brazil, Botswana, Romania, Turkey and Thailand (BP, 2012). South Africa has the world's only commercial CTL plant, which was built during the apartheid era to boost the country's energy security in the face of international sanctions. CTL pioneer company Sasol was subsequently privatised and currently produces approximately 160,000 barrels per day of synthetic liquid fuels, including petrol, diesel and jet fuel. The Chinese government has explored the feasibility of constructing CTL plants in conjunction with Sasol, but in 2011 Sasol shelved the project as a result of policy uncertainty, as the Chinese government vacillated over how best to use its coal resources (Marais, 2011).

Ultimately, as fossil fuels continue to deplete, all developing countries will need to undertake a transition to **renewable energy** sources. However, those countries which lack indigenous fossil fuels reserves will need to embark on this transition earlier if they are to avoid socioeconomically debilitating energy price rises.

Solid **biomass** is increasingly being used in higher income countries with biomass resources to generate electricity and/or heat for industrial purposes, and in some cases combined heat and power (CHP) plants. Biomass can also potentially substitute for oil as a feedstock for chemical products (Brehmer, Boom and Sanders, 2009). According to REN21 (2012: 31), "[w]ood pellets represent a very small share of modern biomass energy, but they have experienced rapid growth since the mid-1990s." The main advantages of wood pellets (which can be combusted to produce heat or electricity) are affordability, convenience and relative ease of shipping. Several UMICs, including Argentina, Brazil, Chile and China, have recently entered the pellet industry. However, the allocation of land to biomass energy production has to be balanced against a country's need for land for food production.

As discussed in sections 2.2.1 and 2.3.1 above, **biogas** holds good potential for supplementing other energy sources, both for household and small-scale industrial heat, and for electricity generation. China leads the world in the number of domestic digesters, with 43 million in 2011 (REN21, 2012: 33). It has been estimated that 300,000 (mainly rural) households could utilise biogas digesters in South Africa (Trollip & Marquard, 2010).

Global production of **liquid biofuels** has been increasing rapidly in recent years, although this form of energy is dominated by the United States, which produces about half of the world's biofuels (567 kbpd) from approximately 40% of its corn crop (BP, 2012; Brown, 2012). Brazil, which produces ethanol from sugar with a relatively high EROI of approximately 8:1, is the world's second largest biofuel producer, accounting for a 35% share of world biofuel production (265 kbpd) in 2011 (BP, 2012). Argentina (45 kbpd), China (23 kbpd), Thailand (18 kbpd) and Malaysia (2 kbpd) where the only other UMICs recorded as producing meaningful quantities of biofuels in 2011 (BP, 2012). In South Africa, the government is taking slow steps to establish a biofuels industry with a target capacity of about 20 kbpd. However, as mentioned in previous sections, the production of biofuels on a large scale threatens food and water security and can have deleterious impacts on soils and biodiversity. In general, therefore, liquid biofuels are unlikely to provide a major substitute for oil.

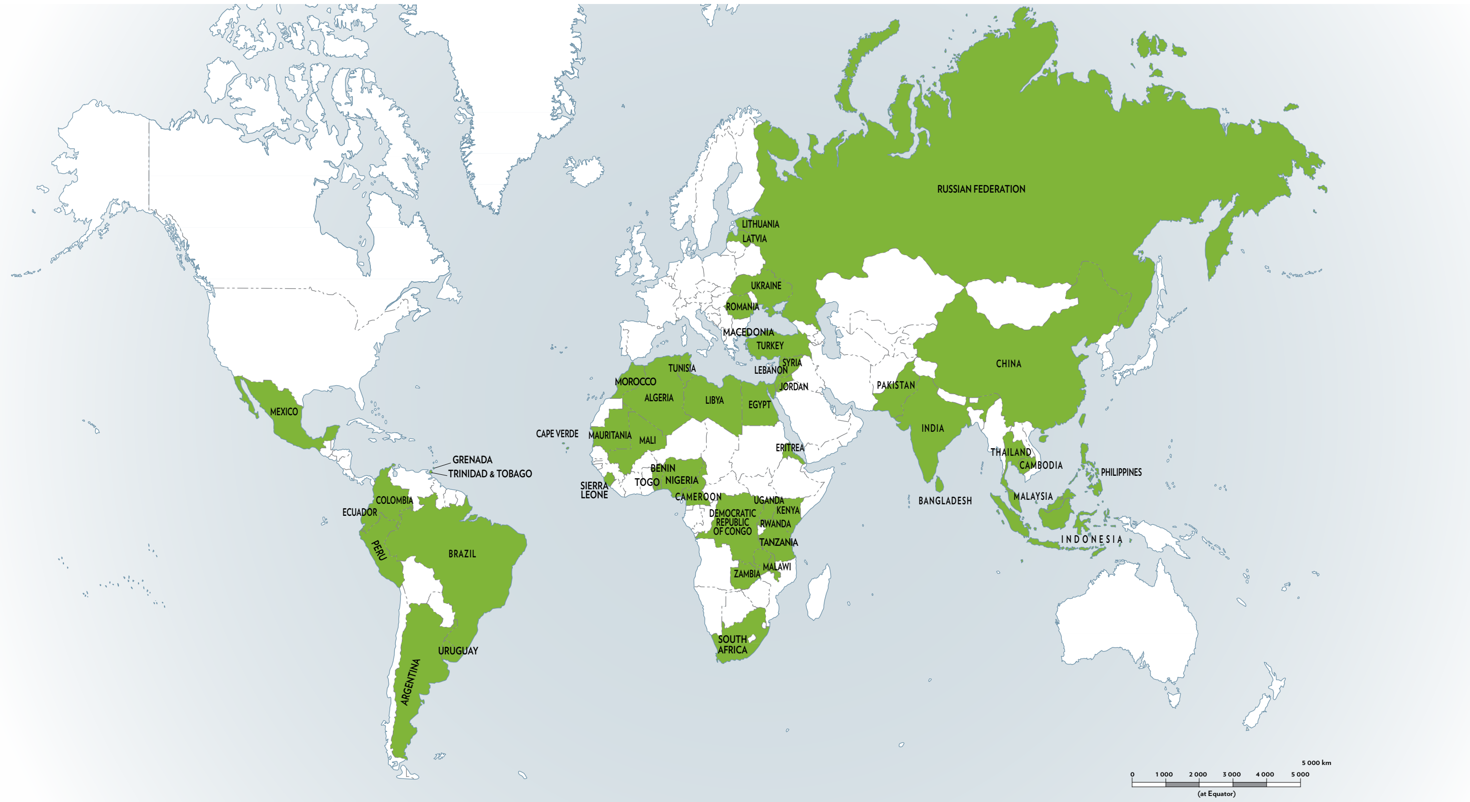
Hydroelectricity, derived from mostly large-scale installations at dams, is the world's foremost source of RE. Most UMICs already utilise hydropower, and some are investing heavily in this source of electricity. By the end of 2011 China had 212 GW of installed hydropower capacity, the largest in the world, but planned to increase this to 300 GW by 2015 (REN21, 2012: 42). Other leading UMIC hydropower producers include Brazil (second in the world), Chile and Argentina. Brazil added 433 MW of small-scale capacity (less than 30 MW) in 2011. Countries in dry climates with limited water resources, such as South Africa, Namibia and Botswana, have little potential for new large-scale hydro. SIDS typically do not have large rivers, but can make use of small-scale and micro-hydro opportunities.

Various forms of **solar energy** are beginning to take off in UMICs, as in the high income countries (see Figure 2-5). China (with over half of the world's capacity) and Turkey lead the world in solar water heating (SWH) installations, with Brazil not far behind in fifth place (REN21, 2012: 54). South Africa's government has a programme to install one million rooftop solar water heaters by 2013 (DoE, 2013). SWH is relatively cheap and has huge environmental advantages over fossil fuel alternatives. The growth rate of solar PV installations world-wide has averaged 45% over the past decade, accelerating to over 70% in 2010 and 2011 (BP, 2012). However, the vast majority of the world's solar PV capacity has thus far been built in high income countries, especially in Europe, where subsidies and feed-in-tariffs have been introduced to stimulate uptake. An exception is China, whose cumulative installed capacity of solar PV grew to 3000 MW in 2011, an astonishing increase of 275% from the previous year (BP, 2012), which took the country to sixth place on the world rankings (REN21, 2012: 47). Malaysia (13 MW) and Turkey (12 MW) were the only other UMICs with significant solar PV capacity in 2011 (BP, 2012). However, significant new capacity is presently being constructed in South Africa. Concentrating solar power (CSP) is still in its infancy in UMICs, largely due to its high costs. Following a tender in 2011, CSP plants amounting to 150 MW of capacity are currently being built in South Africa, while the national utility Eskom is planning its own 100 MW plant (REN21, 2012: 52). Other UMICs that are developing CSP include China, Thailand, Turkey and Chile.

Wind power, as noted earlier, is becoming increasingly competitive with traditional sources of electricity and is experiencing rapid growth across the world. In 2010 China overtook the US as the world's leader in installed wind power capacity, and reached 62.4 GW of capacity in 2011 – more than one-quarter of the world's total (BP, 2012). Turkey (1729 MW), Brazil (1425 MW), Costa Rica (192 MW) and Argentina (112 MW) were the other UMICs with significant wind power capacity in 2011 (BP, 2012). The Dominican Republic added its first commercial wind power capacity in 2011 (REN21, 2012: 57). Wind power is taking off in South Africa under the government's renewable energy bidding programme. A potential constraint on future wind turbine manufacture is the reliance of electric motors on rare earth metals, whose supply is increasingly uncertain in a market monopolised by China (Klare, 2012).

Geothermal energy can be used to generate electricity or for heating. As of 2011, Costa Rica (208 MW), Turkey (114 MW), China (24 MW) and Thailand (0.3 MW) were the only net oil-importing UMICs with installed geothermal power

Figure 2-5: Map of developing countries with solar photovoltaic installations



SOURCE: REN21 (2013)

generating capacity (BP, 2012). Other UMICs with good potential for geothermal energy include Chile and Peru, which lie along the so-called "ring of fire" bordering the Pacific Ocean (Brown, 2008: 253). There is considerable potential for geothermal heat to be used for various applications including heating of water and greenhouses (IEA, 2011b). China was the world's leader in direct geothermal heat consumption in 2010, estimated at 21 TWh (REN21, 2012). Substantial research and development investment is needed to commercialise more advanced technologies that will be needed to exploit so-called enhanced geothermal systems, which aim to tap large quantities of heat energy from deep under the Earth's surface (IEA, 2011b).

Ocean energy technologies (including mechanisms to capture tidal, wave and ocean current energy) are still in their infancy, and thus far have been developed almost exclusively by high income countries (REN21, 2012: 45). The only operating ocean power installation in UMICs is a small (3.9 MW) tidal power plant in Zhejiang, China. Nevertheless, there may be extensive future potential for ocean energy in UMICs with coastlines – in particular the SIDS – and these countries should follow developments in these technologies and adopt them when they are commercially viable. For example, wave power potential on the extensive coastline of South Africa has been estimated at between 8,000 and 10,000 MW (Holm *et al*., 2008), or nearly a quarter of the country's current generating capacity.

Various policies can be introduced to stimulate the development of RE sources. Feed-in tariff schemes, whereby producers of renewable electricity receive payment for power fed into the grid, have proven effective in several countries at encouraging households and firms to invest in small-scale installations such as rooftop solar panels. Other measures include economic incentives (e.g. temporary subsidies or tax breaks for RE investments, and taxes on carbon) and supportive regulatory environments. Another important measure in developing countries is to facilitate access to capital and possibly provide start-up grants to allow Independent Power Producers to enter the market (Bacon, 2005: 3). In addition, some countries may need to address monopolistic practices by large existing power utilities, which inhibit entry into the market by new, small power producers.

Each UMIC will need to evaluate the energy, economic, environmental and social costs and benefits of a range of alternatives to oil, based on local conditions. One of the critical factors in choosing energy alternatives will be the energy return on investment (EROI), which measures the ratio of the energy delivered by a process to the energy used directly and indirectly in that process (Cleveland, 2013). A recent report by Lambert *et al*. (2012) provides a comprehensive overview of EROI studies for a wide range of energy sources. Their preliminary assessment indicates that coal (about 28:1), hydroelectricity (84:1) and wind power (20:1) generally have favourable average EROI values, while the average ratios from published studies for most other renewable sources tend to be lower (e.g. 9:1 for geothermal electricity, 10:1 for solar PV, 1.3:1 for ethanol and 0.9:1 for biodiesel). These EROI figures compare to an estimated global average for conventional oil and gas of about 17:1, which underscores the need for energy efficiency and conservation initiatives as fossil fuels continue to deplete.

2.4.2 Transport

The relatively higher prevalence of motorised transport in UMICs is a double-edged sword. On the one hand, there is considerable scope for fuel conservation through demand reduction measures and efficiency gains. On the other hand, the economies and societies of these countries are relatively more dependent on oil-based transport infrastructure, much of which may need to be replaced in the coming decades. The subsections that follow explore the main near- and long-term strategies that can be pursued to mitigate the impacts of oil shocks on the transport sector.

Short-term strategies

PREPARE AND IMPLEMENT RAPID FUEL DEMAND REDUCTION MEASURES IN THE TRANSPORT SECTOR.

A government-sponsored information campaign can inform passenger vehicle and truck drivers about **eco-driving** techniques that can potentially result in fuel savings of up to about 5 per cent (IEA, 2005). Ways in which drivers can improve fuel efficiency include: appropriate use of gears; curtailment of unnecessary idling; reduced use of air-conditioning; driving with windows closed; and avoidance of excessive acceleration and braking (Vanderschuren *et al*., 2008: 25). Another source of increased fuel efficiency is improved vehicle maintenance, which includes correct tuning of the engine, maintaining the correct tyre pressures, regular replacement of air filters, and use of appropriate motor oil (Vanderschuren *et al*., 2008: 25). These measures cannot of course be enforced, but if drivers are provided with the information then the incentive to adopt them will be provided by higher fuel prices.

Traffic management systems can reduce fuel consumption by between 5-15% by helping to ensure that vehicles travel at more efficient speeds (Vanderschuren *et al*., 2008: 25). One of the most effective ways to reduce fuel consumption in road vehicles is to reduce maximum road speed limits (IEA, 2005), for example to 90 kilometres per hour for highways. Success, however, will depend on adequate enforcement, and require expenditure on new signage and possibly extra law enforcement personnel. Nevertheless, this has proven to be one of the most cost-effective and quickly implementable fuel saving measures. Other management options that have been found to improve fuel efficiency include fleet tracking systems for freight vehicles and on-board navigation systems for passenger vehicles (Vanderschuren *et al*., 2008: 25-26), which may be viable in wealthier UMICs. Possibly the greatest scope for realising energy efficiencies in passenger transport lie in boosting vehicle occupancy rates. This applies mainly to private cars, but also to buses, trains and airplanes.

Car-pooling (or ride-sharing) aims to reduce the prevalence of single-occupant private vehicles by encouraging drivers to take passengers. Authorities can promote car-pooling by establishing car-pool or high-occupancy vehicle lanes on urban freeways, designating park-and-ride lots, introducing internet-based systems to match riders, and conducting awareness campaigns (IEA, 2005). The IEA (2005) found car-pooling to be the single most effective measure for rapid oil demand restraint in terms of quantity of fuel saved. However, widespread car-pooling could face obstacles in some UMICs where there is insufficient trust in society.

Telecommuting (working from home via the Internet) and **tele-shopping** (purchasing online with efficient delivery systems) rely on telecommunications to reduce the need for physical travel. This could be an increasingly important means of reducing fuel demand as broadband connectivity continues to grow at rapid rates in many UMICs, and their economies shift more towards services that are compatible with employees working from home. Companies can be encouraged to substitute Internet and computer allowances for travel allowances, and also to introduce flexible work schedules, such as work weeks compressed into fewer, longer days, thus requiring fewer car trips (IEA, 2005), or staggered start and end times (to reduce traffic congestion). Teleconferencing is a particularly attractive option for reducing the need for business people who travel by airplane.

Excessive use of private cars can be discouraged through the imposition of **congestion charges** in cities and/or increased **vehicle licence fees and taxes**. However, these are likely to be politically unpopular and difficult to implement, especially in times of high fuel prices.

It is likely that implementing the full range of conservation measures will unleash synergies (e.g., a single information campaign can include the full range of measures) and lead to even greater fuel reductions (IEA, 2005: 132). Overall, all of these demand restraint measures may yield substantial fuel savings at very low costs compared to the cost of fuel.

Long-term strategies

INVEST IN ENERGY-EFFICIENT AND ELECTRIFIED TRANSPORT INFRASTRUCTURE TO REDUCE OIL DEPENDENCE.

One way to reduce oil consumption over time is to encourage consumers and businesses to purchase more **fuel efficient motor vehicles**, such as smaller and lighter models and those with more efficient transmissions. While rising fuel prices will encourage such a shift towards efficient vehicles, the process can be accelerated through the implementation of 'feebate' mechanisms, government procurement policies that favour efficient vehicles, and fuel economy standards for vehicle manufacturers (Kendall, 2008). The sooner such measures are introduced, the greater the scope for future fuel savings, considering that most vehicles have a lifespan of 15 to 20 years in UMICs. Improved, modern designs with reduced friction and lower weights can also yield substantial fuel efficiency gains in air and rail transport.

Similar policy instruments can be used to accelerate the purchase of vehicles powered by **alternative fuels and propulsion mechanisms**, such as hybrid-electric vehicles (HEVs), plug-in hybrids, fully battery-electric vehicles (BEVs), and compressed natural gas (CNG) vehicles. CNG vehicles are already popular in some UMICs (e.g. Brazil and Argentina), but are a less viable prospect in countries without ready access to natural gas. In any event, Kendall (2008: 132) notes that it is more efficient to convert gas into electricity in power plants and use this to run electrified mass transit, rather than to use the gas in many individual ICEs. Plug-in HEVs and BEVs hold the most promise at present (Gilbert & Perl, 2008), although their uptake in the next decade will be limited by the small scale of production facilities together with consumer resistance and higher prices. Businesses might be quicker to invest in hybrid truck models that offer substantial fuel and cost savings while maintaining vehicle range. A large-scale replacement of ICEVs with BEVs in UMICs could run into serious constraints in terms of certain materials used in their manufacture, such as rare earth metals and lithium (Klare, 2012). In addition, BEVs and plug-in hybrids require a supporting infrastructure of recharging facilities, which requires a significant capital outlay either by local governments or by vehicle manufacturers.

Modal shifts in both passenger and freight transport offer the greatest scope for reducing long-term oil dependence. For passengers, the main modal shifts are from private vehicles to much more energy-efficient mass public transit (trains, trams and buses) and oil-independent non-motorised transport (NMT), such as cycling and walking. NMT is very cost-effective, and offers numerous benefits in addition to fuel savings, such as reduced air pollution and improved exercise and health (Brown, 2009: 151). Bicycle rental schemes have proved highly effective in cities such as Paris, while the provision of dedicated bicycle lanes and parking spaces can foster increased uptake (Brown, 2009: 251-253). Electric bicycles offer greater range and a high level of energy efficiency (Wakeford, 2012: 236). In a future of rising oil prices, air travel – which is amongst the least fuel efficient modes of travel – will increasingly need to give way to rail travel and telecommuting, unless there is a revolutionary breakthrough in aviation technology. Grid-connected electric vehicles (GCVs), including heavy and light rail trains, trolley buses and trams, are the most energy efficient form of motorised transport and do not require heavy and costly batteries as do BEVs (Gilbert & Perl, 2008), but they involve large capital outlays. Although public transport infrastructure is costly to construct, this must be weighed against the large amounts of money spent by households on relatively inefficient fleets of private vehicles in most UMICs. In the case of freight transport, the major modal shifts required to reduce oil dependency are from trucks and air freight to railways and (where possible) ships or canal barges. Modal shifts can be encouraged through taxes on road vehicles and subsidised provision of safe, reliable public transport and rail freight infrastructure.

The large fleets of motor vehicles present in many UMICs represent a significant liability in the face of future oil scarcity and rising fuel prices. Replacement of a vehicle fleet with more efficient alternative vehicles could take decades (e.g. see Wakeford, 2012: 227, for calculations pertaining to South Africa), and hence should begin immediately. Even more important, it makes long-term sense for UMICs to plan a transition to sustainable and resilient transport systems that can be powered by a variety of energy sources, rather than being over 90% reliant on oil as is currently the case in many countries. The road travelled by high income countries in terms of a proliferation of private motor vehicles is a cul-de-sac given the depletion of oil resources.

2.4.3 Agriculture

Most UMICs have moderately to highly urbanised populations and subsistence agriculture is minimal in most of these nations (see section 1.4.1). Therefore the vast majority of the population in most UMICs relies on a system of food production and distribution that involves the use of oil (and other fossil fuels) at every stage of a complex production and distribution chain: from diesel to fuel tractors and irrigation pumps, to petrochemical-derived farm inputs such as pesticides and packaging materials, to diesel fuel for trucking produce to urban areas, to petrol and diesel to enable consumers to drive to shops and food markets. This food system is therefore highly vulnerable to disruptions caused by fuel shortages, and furthermore food prices tend to be closely tied to petroleum prices. These dependencies require both near-term strategies to bolster resilience to sudden shocks, and also long-term strategies to reduce the structural reliance on oil products.

Short-term strategies

IMPROVE RESILIENCE OF FOOD PRODUCTION AND DISTRIBUTION SYSTEM TO OIL PRICE AND SUPPLY SHOCKS.

A key strategy for boosting the resilience of the food system in UMICs is the creation and maintenance of adequate **food inventories** (Heinberg & Bomford, 2009: 33). This strategy of redundancy can mitigate the risks of relying on fragile just-in-time distribution systems that are highly vulnerable to disruptions caused by fuel shortages. It is also compatible with minimising the risks of food supply disruptions caused by extreme weather events, such as the droughts in Russia in 2010, which led that country's government to impose a temporary ban on wheat exports (Brown, 2012). UMICs in general cannot rely heavily on food aid from other countries. Compared to LICs and LMICs, only a small proportion of UMICs received significant food aid in 2011; these included the Maldives, Namibia and Dominican Republic. The only Sub-Saharan African countries that did not receive food aid in 2011 were UMICs, namely Botswana, Seychelles and South Africa (WFP, 2012). This is partly attributable to UMICs' more developed domestic agricultural sectors, and partly because the higher income levels of UMICs usually enables them to afford adequate food imports.

Given the extremely high dependence of commercial agriculture on petroleum fuels in countries with mechanised agricultural sectors, there is a case for governments to provide **short-term fuel subsidies** for farmers to protect them from severe oil price shocks. Otherwise, some farmers might be forced into bankruptcy, which would reduce agricultural output and could compromise national food security in the long run. However, fuel subsidies should ideally be tied in some way to the long-term strategies for reducing oil dependence; else they will encourage continued reliance on diesel and petrol.

Similarly, in order mitigate the risks posed by physical shortages of petroleum fuels for the production and distribution of food products, governments should have in place plans and procedures for **prioritising fuel allocations** for farmers and food distribution companies. Although this strategy might be politically difficult to achieve in some countries (e.g. South Africa and Namibia, whose agriculture sectors have long legacies of racial inequality), it could be vital for protecting national food security and social stability.

Long-term strategies

SYSTEMATICALLY REDUCE AGRICULTURE SECTOR'S RELIANCE ON OIL AND ENHANCE FOOD SOVEREIGNTY.

Commercial agriculture in UMICs typically uses oil in the form of diesel fuel for tractors, harvesters, irrigation pumps and other farm machinery. However a wide range of other inputs are derived from crude or synthetic oil, including irrigation piping and fittings, pesticides, packaging materials, etc. In addition, rising crude oil prices will put upward pressure on the price of natural gas, which is the primary feedstock for synthetic nitrogen fertilisers.

To reduce this extremely heavy reliance on oil-based inputs, governments should implement policies that encourage the commercial agriculture sector to adopt **agroecological farming** methods. For example, conservation agriculture, which is based on a principle of minimal soil disturbance, reduces the need for tractor usage and therefore diesel fuel (FAO, 2010). However, weed management becomes more challenging, which given the unsustainability of oil-based herbicides implies greater demand for labour (Giller *et al.*, 2009). Hence the state should support the development and use of bio-fertilisers and bio-pesticides. Another option is to utilise alternative energy sources for farm machinery. Biodiesel can be manufactured on a small, local scale from crops produced on a portion of a farmer's land. Solar-powered electric tractors have been designed that can be recharged from the grid or from tractor-mounted photovoltaic panels (Heckeroth, 2009). However, biodiesel production implies reduced land area available for food production and could therefore compromise food security. Another important aspect of organic agriculture is soil rehabilitation to restore soil fertility without inorganic fertilisers (Heinberg & Bomford, 2009: 22). This can be achieved through appropriate crop rotation, incorporating nitrogen-fixing crops, and recycling of critical nutrients (including phosphorus) through the use of composting, animal manures, and green manures (Pfeiffer, 2006: 58). However, using animal manure implies allocating more arable land to grazing and therefore less to growing food crops. Rehabilitating depleted soils takes several years of sustained effort (Heinberg & Bomford, 2009: 22). In addition, oil-based pesticides should be replaced with integrated pest management, utilising biopesticides, microbes and natural pest control, intercropping to reduce losses to pests, and cover cropping to counteract weeds (Pfeiffer, 2006; Heinberg & Bomford, 2009: 11).

Governments can promote agroecological farming techniques through knowledge and training support programmes for both large-scale commercial farmers and small-scale emerging farmers. Scientific and research budgets need to give greater priority to agroecological farming (Hine *et al*., 2008). Moreover, various networks need to be strengthened, for example those involving scientists, agricultural extension providers and farmers, and connections between farmers, civil society organisations and government departments (Hine *et al*., 2008).

The second major strategy to reduce the oil dependence of the food system is to **relocalise food production and consumption**, which means minimising the distances travelled by food products in order to reduce transport costs and vulnerability to fuel supply interruptions. The development of **urban agriculture** (UA) represents a specific form of localisation with significant opportunities to foster the resilience of urban communities (Hopkins, 2000). Local governments can promote urban food production by allocating under-utilised land for community food gardens and leasing allotments to residents (Brown, 2010: 177). Local by-laws can foster rooftop and backyard food gardens and laws could be enacted to require urban agricultural produce to be organic, as in Cuba (Pfeiffer, 2006: 61). Municipalities can either organise their waste systems to process food waste into compost or biogas (Heinberg & Bomford, 2009: 17), or incentivise residents to do so themselves. Sewerage systems should also be reconfigured so that essential nutrients like phosphorus are recycled back into the food production system.

2.4.4 Macro-economy

Since oil price shocks have wide-ranging macroeconomic effects (see section 1.1), policy-makers should incorporate oil shock mitigation strategies into their macroeconomic policy frameworks. This will promote greater near-term economic resilience, and also contribute to sustainable development in the long term.

Short-term strategies

INSULATE THE MACRO-ECONOMY AGAINST EXCESSIVE OIL PRICE VOLATILITY.

The main tool for boosting near-term resilience to oil price shocks is to build up **foreign exchange reserves**, which can be drawn upon in the event of a severe (but transitory) oil price spike so that the country can continue to import fuel supplies. Some UMICs already have sizeable foreign reserves (e.g. China, Thailand, Botswana and Mauritius), but others (e.g. Lithuania, Latvia, Jamaica & Seychelles) have very limited reserves. Boosting reserves will require policies directed at increasing exports and curbing imports. The latter process may be painful in the short term, but is an important way to bolster the adaptability of the economy to external shocks. **Hedging** by buying and selling in the oil markets is similarly risky given the high degree of uncertainty that characterised today's tight oil markets. Therefore, while UMICs should aim to accumulate larger foreign exchange reserves to deal with emergency situations, they should in general focus on long-term strategies to boost macroeconomic resilience to oil shocks.

Since many UMICs are highly integrated into the global financial system, **monetary and fiscal policy** authorities should take special precautions to insulate the domestic financial system from external shocks. For example, excessive reliance on short-term inflows on the financial account (so-called portfolio investments, such as purchases by foreigners of domestic bonds and equities) may expose a country to rapid financial outflows and currency crises when there is an international economic shock. A rapid depreciation in a country's currency would exacerbate the effects of rising world crude oil prices, since the price paid in domestic currency terms would increase accordingly. 'Hot money' inflows can be discouraged through the use of Tobin-type taxes on short-term foreign investments or currency transactions. For example, partly in an effort to reduce the appreciation of its currency, Brazil introduced a 1.5% tax on portfolio inflows in 2008 and subsequently raised this to 6% by 2011. Although there appeared to be little impact on the country's exchange rate, the tax did garner a significant amount of revenue for the state: equivalent to about $0.4 billion in 2010 (Romano, 2011).

Long-term strategies

PLAN TO DECOUPLE ECONOMIC DEVELOPMENT FROM OIL CONSUMPTION.

Many of the practical measures discussed in the preceding sections on energy, transport and agriculture should be integrated with macroeconomic policy and planning in order to construct a coherent strategy for **decoupling** of economic development from oil consumption. Several aspects of macroeconomic policy can also play a part in this strategy.

Fiscal policy, concerning revenue collection and state expenditure allocations, is one of the primary tools that UMIC governments can use to guide the long-term development paths taken by their economies. Prudent fiscal policy, namely the avoidance of excessive borrowing (both internally and externally) and spending in line with available revenues, is especially important in an age where oil shocks are increasingly likely. Thus budget deficits should be brought under control to avoid excessive debt build-up, which constrains a government's ability to respond to shocks. UMIC governments should try to resist pressure to inflate public sector wages and salaries following oil price shocks, as this could set up dangerous wage-price spirals (as afflicted several developed countries following the 1970s oil shocks). Furthermore, sufficient space should ideally be created in budgets to allow governments to respond flexibly to exogenous shocks. As an example, the South African fiscal authorities managed to run a budget surplus in the boom years of 2006-2007, which gave them increased fiscal manoeuvrability to respond to the recession of 2009 with increased expenditures. Since it typically absorbs a substantial amount of state spending and is long-lived, **infrastructure investments** by national, provincial and local governments should be compatible with the goal of decoupling economic development from oil consumption. In practical terms this implies reduced spending on oil-related infrastructure such as roads and airports, and increased expenditure on the likes of electrified railways and information and communication technology (ICT) systems that structurally reduce the need for oil.

Monetary policy authorities face enormous challenges in an age of increasing oil scarcity and price shocks. Authorities should recognise that a certain amount of inflation is unavoidable following an oil price spike, but that severe spikes are often short-lived. Central banks should consider refraining from rapid interest rate hikes in response to transitory oil price spikes, as such rate adjustments may be permanently damaging to local businesses and highly indebted households. A moderate rate of inflation can actually help a country to adjust by allowing relative prices to change, and can be less damaging than deflation, which can lead to a sharp decline in economic activity (Douthwaite, 2010). The major central banks of the world have certainly shown an increased tolerance of inflation in recent years following the Global Financial Crisis of 2008-2009, and many UMIC central banks have also kept interest rates at or near historical lows. Nevertheless, it is important that monetary policy authorities discourage excessive growth of private sector indebtedness, which can impose a strangling burden on economic activity when the external economic environment becomes adverse.

Industrial policy in UMICs should also be changed to reflect global energy and oil realities and the likely impact of shocks. Selective taxes and subsidies can be used to boost sectors of the economy that are less dependent on oil, such as "green economy" sectors like renewable energy, energy efficiency, recycling and repair industries, manufacture of sustainable transport infrastructure, and so on. Industrial strategies in UMICs should in general promote relatively energy-efficient service industries, including the 'knowledge economy'. A key part of the structural shift in the economy towards lower oil and resource use will be education and training in more sustainable sectors. In a UMIC context, promotion of research and development and sustainability-oriented innovations, for example through fiscal incentives, can help stimulate the greening of the economy.

The fact that approximately 95 per cent of global transportation systems are powered by oil (IEA, 2012b), together with the trend of growing world oil scarcity as reflected in rising oil prices, may imply that the process of globalisation (in terms of trade in physical goods) may at some point shift into reverse (Rubin, 2009). Thus long-term **trade policy** in UMICs should arguably shift away from an overwhelming emphasis on export-led growth towards the goals of greater economic localisation and self-sufficiency. In the face of rising freight transport costs, especially for bulky commodities, those UMICs that rely heavily on commodity exports, such as mineral ores (e.g. Chile, Botswana, Namibia and South Africa) or agricultural products (e.g. Argentina and Brazil), could consider beneficiation strategies so that they export higher-value, lower-weight finished goods rather than raw primary commodities. Countries that rely heavily on international tourism for foreign exchange revenue and employment – such as many of the SIDS (e.g. Maldives, Mauritius and Seychelles, and numerous Caribbean nations) – should carefully consider measures that promote diversification into other sectors, especially if they are located far from the countries (often wealthier nations) from where most international tourists originate.

2.4.5 Society

UMIC societies are in general more dependent on oil than those in lower income countries, and consequently face some different social pressures arising from oil shocks. Nonetheless, similar strategies are called for in order to maintain social cohesion and to plan for long-term sustainable settlements to reduce future exposure to oil shocks.

Short-term strategies

MAINTAIN SOCIAL COHESION IN THE FACE OF FUEL PRICE SPIKES AND/OR SHORTAGES.

Since considerable amounts of petroleum fuels are consumed by households in UMICs (mainly in the form of petrol or diesel for private vehicles, but also LPG for cooking in some countries), there is greater scope than in poorer societies to save fuel through **rationing schemes**, which as discussed in previous sections are more equitable than allowing prices to allocate fuel supplies. There are two types of rationing policies: those that ration purchases of oil products (e.g., bans on fuel purchases on certain days of the week or restricted hours of fuel sales); and those that ration activities (such as driving) that intensively use oil products (e.g., restricted entry into city centres based on odd/even vehicle licence plates, restrictions on motor sports, and so on) (AfdB, 2009: 160). Fuel rationing would be particularly important if consumers react to high oil prices or shortages by panic and hoarding behaviour (IEA, 2005: 15). On the negative side, fuel rationing is often economically inefficient (IEA, 2005: 15), and is likely to be difficult to implement and face serious opposition from consumers.

A more sophisticated form of rationing uses the concept of **Tradable Energy Quotas** (TEQs), which was developed specifically to address the twin challenges of climate change and fossil fuel depletion while ensuring social equity in access to energy (Fleming, 2007). The TEQs model aligns individual incentives with the collective requirement to reduce fossil fuel dependency (APPGOPO, 2009: 5). TEQs function as follows. To begin with, a Climate Committee determines a national "Carbon Budget" for total annual carbon dioxide emissions, which decrease each year over a twenty-year period. The annual budget is then divided into individual TEQ units, a unit being "defined as one "carbon unit" – that is, allowing the purchase of sufficient fuel or energy to produce one kilogram of carbon dioxide over its lifecycle" (APPGOPO, 2009: 9). TEQs are required for all energy purchases, with each energy type being rated according to its carbon content. A Registrar issues equal entitlements (summing to approximately 40% of units) to each adult citizen and maintains carbon accounts for all participants. In addition, TEQs are sold on a weekly tender via financial intermediaries to other energy users, including businesses and government. Once issued, TEQs can be traded by all energy users in a single market, allowing low-energy consumers to derive income while high-energy users obtain sufficient units to cover their energy needs. The entire system is electronic, making use of direct debits and debit cards. The price of TEQs is determined in this market and depends on efforts to reduce energy demand. It is not necessary to measure emissions at their exit point ("exhaust pipe"); rather, the carbon accounting is done at the point of sale. When individuals or entities purchase energy, they surrender the appropriate number of units to the retailer, who surrenders to wholesalers, and so on. Primary energy producers surrender units to the Registrar. Each successive year, the total Carbon Budget is reduced and thus fewer TEQs are issued.

TEQs have a number of benefits. First, they guarantee a certain annual reduction in fossil fuel use and carbon emissions. Second, TEQs promote fairness in access to energy, while providing strong incentives for individuals to reduce their energy consumption. Third, a rolling carbon budget is set for a twenty-year period, which creates a much greater degree of certainty for business and personal planning decisions. Fourth, the system is administratively simple, using modern, automated electronic systems that make it largely "hands free" (Fleming, 2007). Nonetheless, TEQs do have certain limitations in the UMIC context. For one, TEQs require a single national market for carbon-based fuels, but this is not necessarily simple; for example, the incorporation of electricity generated from fossil fuels is complicated when renewable primary energy sources are also used. Second, TEQs do not directly protect individuals against high oil prices, which are still determined on international markets. Thus there is no guarantee that poorer people will actually be able to afford the fuel that their TEQs entitle them to. Nonetheless, they will be guaranteed a basic income through their right to sell their TEQs. Third, implementation of the TEQ system would face challenges in a developing country context characterised by limited access to banking and adult illiteracy and innumeracy. Each UMIC would need to assess its potential to adopt TEQs.

Long-term strategies

PLAN SOCIOECONOMIC AND SPATIAL DEVELOPMENT SO AS TO REDUCE OIL DEPENDENCE.

For the most part, local economic development (LED) strategies in the past have assumed that the forces of globalisation will be maintained or even increase in the future, and seek to counter-balance these forces or adapt to them. Eco-localisation (or "relocalisation") calls for a proactive strategy to reduce reliance on a globalised economy that is expected to 'de-globalise' as a consequence of rising transport costs as world oil production declines (Heinberg, 2004; Hopkins, 2008; North, 2010). According to this view, the vulnerability of global value chains to dislocation from liquid fuel shortages implies that businesses that are currently embedded in global and even national value chains should, wherever possible, seek to localise their sources of inputs and expand their local markets. Regional and local multipliers can be boosted by measures such as 'buy local' campaigns and state procurement policies that insist on local content of goods and services. Proponents of localisation advocate local economies that are resilient through diversity and interdependence. Authors such as Hopkins (2008) foresee that relocalisation will be driven primarily by communities, although working in partnership with local government authorities.

An important aspect of LED is finding ways to ensure that a sufficient supply of **money** flows within the local economy so as to stimulate economic activity, even when the supply of national currency may be scarce due to unfavourable economic conditions. One option is the formation of state-owned municipal banks, which would be able to award low- or zero-interest loans to individual citizens and for community investment projects. A second option is the formation of credit unions, which are cooperative, community-owned financial intermediaries. These institutions essentially pool the financial resources of citizens and make loans on favourable terms for projects adjudged by the governing board of directors to be sustainable and beneficial to the community (see Douthwaite, 1996). A similar model is community trusts that accumulate both public and private investment capital and spend these on community projects via cooperative enterprises. A third possibility is the use of local or community currencies, which are complementary to the national currency and can help to boost local economic multipliers and tap otherwise idle human and physical resources (Douthwaite, 1996).

A number of specific policies and measures should be adopted in **urban planning**. First of all, the phenomenon of urban sprawl should be halted in order to avoid further entrenching dependency on automobile transportation and to limit encroachment on agricultural land surrounding urban settlements. Urban densification should be pursued instead, with the aim of reducing average travel trip distances and lessening reliance on private motor vehicles (Aftabuzzaman & Mazloumi, 2011: 700). Planning authorities should adopt integrated land-use planning practices (Aftabuzzaman & Mazloumi, 2011: 700) such as mixed land-use zoning, i.e. allowing commercial, light industrial and residential areas to be in close proximity in order to reduce transport requirements. Local government authorities could allow and encourage small commercial outlets, which might be termed "neighbourhood centres", within residential areas (City of Portland, 2007: 37). Planning should encourage housing of sufficient density near public transport routes that will generate adequate fare revenues to sustain the mass transit services (City of Portland, 2007: 37), foster developments along public transport corridors, and provide public spaces accessible to pedestrians in urban centres. Special efforts should be made to maintain existing industrial areas, especially those that are near rail lines, to facilitate local economic diversification in the event that globalisation unwinds in the longer term (City of Portland, 2007: 38).

2.4.6 Summary and conclusions

We conclude this section on UMICs by summarising the mitigation strategies, listing a number of obstacles and constraints facing their implementation, and highlighting the positive opportunities for socioeconomic transformation. Table 23 contains a summary of the oil shock mitigation strategies, policies and measures proposed for UMICs in the preceding sections. The principal strategies can be encapsulated as follows:

- Boost resilience to oil price and supply shocks by holding adequate oil stocks, accumulating a buffer of foreign exchange reserves, and preparing emergency response plans to allocate scarce fuel supplies to priority sectors.
- Plan development in all areas of the economy that decouples economic development from oil consumption, for example by investing in indigenous and renewable energy and efficient transport infrastructure, and ensuring that cities develop sustainably.

Table 2-3: Summary of oil shock mitigation strategies for UMICs

SOCIOECONOMIC SUBSYSTEM	SHORT-TERM STRATEGIES, POLICIES & MEASURES	LONG-TERM STRATEGIES, POLICIES & MEASURES
Energy	Insulate the economy from excessive oil price volatility and physical supply shortages. ▪ introduce fuel price smoothing mechanism ▪ gradually phase out fuel subsidies, except possibly temporary, targeted subsidies for critical users ▪ ensure adequate strategic fuel inventories ▪ diversify sources of oil imports ▪ forge regional energy alliances with oil-importing and oil-exporting countries ▪ subscribe to a regional petroleum fund	▪ Reduce reliance on imported oil through energy conservation and development of substitutes. ▪ foster energy conservation & efficiency with appropriate incentives & regulations ▪ phase out oil-fired power generation, replacing with alternatives ▪ promote energy efficient buildings solar water heating ▪ boost development of energy substitutes, e.g. indigenous oil, gas, & renewable energy sources ▪ develop smart electricity grids ▪ promote decentralised micro-generation from renewable energy sources in rural areas, e.g. by implementing feed-in tariffs
Transport	Prepare and implement rapid fuel demand reduction measures in the transport sector. ▪ introduce information campaign to promote fuel conservation & efficiency through eco-driving, good vehicle maintenance, car-pooling, flexible work schedules, telecommuting & Internet based shopping ▪ improve traffic management (e.g. reduce road speed limits, improve traffic flows to minimise vehicle idling) ▪ construct car-pool lanes in cities ▪ levy congestion charges in city centres ▪ implement selective driving bans in times of fuel shortage ▪ encourage modal shifts by increasing private vehicle taxes & licence fees and subsidising public transport	Invest in energy-efficient and electrified transport infrastructure to reduce oil dependence. ▪ regulate fuel economy standards for road vehicles ▪ use 'feebate' system and government procurement to promote uptake of efficient & alternative-fuel vehicles ▪ invest in cycle lanes & pedestrian walkways to support non-motorised transport in urban areas ▪ invest in public transport infrastructure, e.g. electrified railways, trams, electric bus rapid transit ▪ support bicycle & electric bicycle manufacture & distribution ▪ curtail investment in roads & airports ▪ implement 'user pays' principle for road upgrades
Agriculture & food	Improve resilience of food production and distribution systems to oil price & supply shocks. ▪ possibly provide temporary diesel fuel subsidies for commercial farmers in planting & harvesting periods ▪ ensure sufficient fuel allocation for food distribution ▪ join a regional food security fund	Systematically reduce agriculture sector's reliance on oil and enhance food security. ▪ enhance food sovereignty by diversifying food production ▪ preserve remaining indigenous knowledge of traditional, oil-independent farming methods & local seed varieties ▪ support knowledge & training in agro-ecological farming methods ▪ support development of bio-fertilisers and bio-pesticides ▪ encourage urban agriculture, e.g. by allowing mixed use zoning, allocating space for community gardens and allotments
Macro-economy	Insulate the macro-economy against excessive oil price volatility. ▪ boost foreign exchange reserves to cushion impact of oil price spikes ▪ avoid foreign and national debt accumulation ▪ refrain from rapid interest rate hikes in response to transitory oil price spikes ▪ maintain exchange rate flexibility to avoid rapid depletion of foreign exchange reserves	Plan to decouple economic development from oil consumption. ▪ incorporate 'decoupling' principle in economic policy & planning frameworks ▪ reduce government budget and trade deficits as far as possible ▪ use fiscal measures (selective taxes & subsidies) to promote green economy sectors & skill development ▪ promote economic localisation to structurally reduce transport needs ▪ reallocate funds from airports & roads to railways & telecommunications ▪ practice wage restraint, especially in the public sector, to avoid wage-price spirals
Social welfare	Maintain social cohesion in the face of fuel price spikes and/or shortages. ▪ launch public awareness campaign to promote social cohesion during oil shock episodes ▪ implement fuel rationing schemes that prioritise allocation to critical sectors & emergency services ▪ improve poverty alleviation measures, e.g. job creation initiatives ▪ forge regional alliances to enhance regional resilience and cohesiveness ▪ sign an Oil Depletion Protocol	Plan socioeconomic and spatial development so as to reduce oil dependence. ▪ build resilient communities through local economic development ▪ plan sustainable human settlements, e.g. compact cities that are pedestrian- and cyclist-friendly ▪ avoid urban sprawl ▪ densify urban areas and allow mixed-use zoning to reduce transport needs

Implementation of these mitigation strategies, policies and measures is likely to encounter a range of social, political, institutional, economic and environmental obstacles and constraints, the severity of which will depend on individual country circumstances and characteristics. An evaluation and risk assessment of the mitigation strategies should be a part of the planning process if their benefits are to be maximised. Some of the generic constraints include the following:

- **Social** constraints can include: cultural norms such as resistance to new technologies or lifestyles; ideological lock-in to conventional conceptions of industrialisation and development; behavioural–psychological issues such as expectations and aspirations of the population, for instance in terms of personal mobility and status attached to car ownership; and lack of social cohesion, especially in highly unequal societies.
- **Political** factors: lack of political will and effective leadership; preoccupation with other policy concerns; weakness of democratic institutions that protect the most vulnerable sectors of society; vested or opposing interests, including possibly large multinational corporations.

- **Institutional and organisational** limitations: constraints on state capacity, e.g. for planning and project management; inadequate governance and occurrence of corruption; lack of access to reliable and timely information that is required for planning; shortages of requisite education and skills (e.g. engineers, managers).
- **Economic** constraints: constraints on state finances; public and foreign debt burdens; lack of foreign exchange; reliance on commodity exports with volatile prices; energy intensity of manufacturing industries; high levels of consumer indebtedness; high cost of new infrastructure such as smart electric grids.
- **Environmental** constraints: water scarcity, which can be a limiting factor for production of various types of energy; scarcity of land and biomass resources, especially given food security concerns; degradation of soils and deforestation; intensifying impacts of climate change; costliness of and limited access to other key resources that are required for components of renewable energy technologies and electric vehicles, such as rare earth metals and lithium (Klare, 2012).

The cloud of oil shock risks has a silver lining of **opportunity** in that rising oil prices can be used as a catalyst to stimulate a transition towards greater sustainability across a broad range of economic sectors. While UMICs are further down the road of oil-based industrialisation than LICs and LMICs, they are not yet as fully oil-saturated as are the high income countries. Consequently there is still some space for UMICs to engage in 'technological leap-frogging' to a more sustainable socioeconomic regime and benefit from a late-comer advantage. Given their greater financial resources and economic diversity compared to lower income nations, UMICs are arguably well placed to become leaders in the next wave of development, as countries such as China and Brazil are already doing.

2.5 Oil Exporting Countries

This section presents the generic oil shock mitigation strategies for net oil exporting countries (OECs), which include low income countries (LICs), lower middle income countries (LMIC) and upper middle income countries (UMIC). The overarching question addressed in this section of the report is as follows:

- What strategies can oil exporting governments adopt in order to most effectively mitigate the negative socioeconomic impacts of global oil price and domestic supply shocks?

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Solar panel manufacture

CREDIT: MEDECINS SANS FRONTIERES

Vaccination clinic, Democratic Republic of Congo

The development of mitigation strategies differs from the other sections in the report. A different analytical framework is therefore followed. As a first organising principle we distinguish between two basic types of oil shocks: (1) oil *price* shocks (i.e. a substantial increase in the price of crude oil and consequently refined petroleum products) and (2) physical oil *supply* disruptions (i.e. a significant restriction on the available quantity of oil and derived petroleum products in a national economy). In the case of net oil exporting countries, price shocks emanate from the international market while supply disruptions are due to internal domestic factors.

More specifically, as a second layer of organisation, this part of the report examines the following more detailed questions for oil exporting countries as far as possible:

- How oil exporters can mitigate the impacts of oil production and exports on the macroeconomy (e.g. resource curse, lack of diversification, deindustrialisation) as well as on the environment?
- How oil exporters can mitigate the effects of oil price volatility, specifically in cases of high dependency on tax revenues from oil, impacts on government revenues and ability to invest, and the impacts on foreign exchange earnings?
- How to mitigate oil depletion while experiencing rising domestic consumption?
- How to mitigate conflicts over access to oil wealth?

Mitigation options are further discussed according to the generic way in which they attempt to **influence human behaviour** to bring about change in a desired direction. There are essentially three such ways, namely education and awareness campaigns, the use of economic incentives (such as taxes and subsidies), and coercion in the form of statutory regulations prescribing and proscribing certain behaviours or actions on the part of individuals, communities and firms. In the case of oil exporters such options are rather limited to influencing rising domestic consumption.

2.5.1 Resource curse

Higher oil prices are not always a blessing for all oil exporters. The African Development Bank (AfdB 2009:137) concluded: "…key economic and social indicators for oil-exporting countries suggest that oil wealth has not been able to support sustained economic growth and development". There is some evidence for a resource curse amongst certain oil exporters, although this is by no means irrefutable and very dependent on each particular situation. The 'resource curse' may manifest in appreciating exchange rates ('Dutch disease'), adverse impacts on manufacturing and non-tradables ('crowding out'), weak institutions and governance as well as symptoms of anarchy and even civil war. Mitigating against a resource curse would not be a generic reaction, implementable to all oil exporters and case-by-case approaches are suggested (Treviño, 2011). Several possible aspects of a 'resource curse' and possible mitigation strategies for each are now discussed.

GDP growth and the exchange rate

An appreciation of the real exchange rate due to a rise in the value of oil exports is associated with oil-exporters that have high oil-export dependencies. For Congo, Sudan, Iraq and Angola more than 80% of total value of exports are oil exports, in Nigeria it is 75%, and in half of the oil exporting countries the value of oil exports is more than 30% of GDP. Baumeister *et al*. (2010) found that GDP output increases in countries that export oil and other forms of energy when oil shocks occur, but declines temporarily for countries whose only energy export is oil. Treviño (2011) pointed out that real exchange rates were appreciating even for smaller oil producers in the CFA franc zone in Africa, namely Cameroon, Chad, Congo, Equatorial Guinea, Gabon and Cote d'Ivoire, and that real exchange rate overvaluation is associated "with higher rather than lower growth in some cases" (2011:17). Buetzer *et al* (2012:1) argued that the type of oil shock matters as they found no evidence that "…exchange rates of oil exporters systematically appreciate against those of oil importers after shocks raising the real oil price…[but] that oil exporters experience significant appreciation pressures following an oil demand shock." Appreciating exchange rates do not seem to matter that much for a contraction in GDP. Buetzer *et al* (2012) speculates that rising domestic asset prices may be responsible for capital losses in oil exporters, and not exchange rates.

The implication of the evidence presented here is that there is a high risk that efforts to counter appreciating exchange rates will be misplaced and counter-productive for oil exporters. Oil exporters have had a traditional propensity to peg their exchange rates to the dollar or a basket of currencies (mostly including the dollar and the euro). With rising oil prices, oil exporters started experiencing huge financial inflows into their economies, and without flexible exchange rates, money supply and inflation have started increasing in most oil exporting nations (Setser, 2007). Setser (2007) argues that the benefits of importing a stable US monetary policy is now outweighed by the costs of importing a policy that does not meet the local needs of oil exporting nations. For small oil exporters not in a position to run an independent monetary policy it has been suggested that greater exchange rate flexibility can be obtained by anchoring to a basket of currencies, instead of a single currency (Habib & Straský, 2008) or a basket of currencies that includes the price of oil (Setser 2007).

Esfahani *et al* (2012) pointed out that long run output growth is positively associated with oil income from exports, given certain regulatory conditions and assumptions on the nature of economic growth as a combination of labour, capital and technological progress, with capital and labour in constant returns to scale. Hence, Esfahani *et al* argue that the "Dutch disease" and the "resource curse" are primarily focused on the short-run implications of resource discoveries. Although not mentioned by the authors themselves, the implications from such a perspective is that mitigation for the Dutch disease and resource curse should be focussed on the short term, as the evidence points out that long-term growth is positively associated with increasing oil income from oil exports.

Foreign exchange earnings

Increases in the price of oil could substantially increase the amount of foreign reserves for oil exporters, especially in situations when exchange rates are inflexible and undervalued. Oil exporters have seen a massive growth in foreign reserves in recent times, effectively insuring against sudden reversal in the balance-of-payments (Wyploz, 2007). In an analysis of global net foreign assets, Lane & Milesi-Ferretti (2004:237) estimated that the "…largest creditor positions are disproportionally identified with oil producers…" However, the opportunity costs of holding large reserves tend to be high as returns in high grade-low risk instruments are low, placing increasing pressure on oil exporter governments to invest in the local economy. This in turn raises the importance of an effective fiscal policy, but also the risk of rising inflation. Iwayemi and Fowowe (2011) argue that in the case of Nigeria since the 1970s, a large share of oil revenue windfalls has been used to finance the import bill, mostly for consumables, leaving little for investment in more productive economic activities. Increasing foreign exchange earnings calls for a sustainable fiscal policy so that these earnings are channelled into their most productive uses.

Lack of diversification

The majority of lower income countries exporting oil also have low econo mic diversification, while higher income oil exporting countries tend to have more diversified economies. One pertinent effect of a growing oil sector is that labour is relocated away from traditional activities into the oil sector. In one example, Trevino (2011) did find evidence for this "resource-movement effect" for net oil exporters in the CFA Franc Zone. The annual growth in the economically active population in agriculture declined from around 2,5% pa in the end of the 1980s to almost zero in 2007 and around 0,5% in 2008, while it remained fairly constant at 2,5% in oil-importing nations of the CFA Franc Zone. The Arab world is also characterised by a low degree of economic diversification, especially by a limited role of manufacturing (Elbadawi & Gelb 2010).

To further diversify oil exporters' economies the standard recommendation is to continue channelling large portions of oil revenues into social and economic infrastructure (education, health, transport, basic services etc.) to promote long-term economic growth across a broader spread of economic activities. According to Gelb (2010:17) a combination of three factors are needed for the effective diversification of resource-rich countries, namely:

> "a reasonable level of macroeconomic stability underpinned by prudent spending, a reasonably open trade policy, and the active use of resource rents to increase the productivity of other exportable sectors and reduce their production costs, whether by funding infrastructure, temporary subsidies or other methods."

A policy of active diversification of the economy remains pertinent for oil exporters, especially lower income countries.

Deindustrialisation

Most of the literature suggests that oil rents not only hinder economic diversification, but may also penalise manufacturing through the mechanisms of Dutch Disease and extreme volatility (Elbadawi & Gelb 2010:4). A concentration of oil exports is indeed mirrored by a small role for manufacturing especially in Arab countries (Elbadawi & Gelb 2010:8). In Nigeria, manufacturing's share of GDP has even declined from 10% in 1982 to around 6% in 2002. Ishmael (2010) performed a study on the "structural implications of the Dutch disease in oil-exporting countries due to permanent oil price shocks" which tested the manufacturing sector, and found that:

> "...permanent increases in oil price negatively impact output in manufacturing...oil windfall shocks have a stronger impact on manufacturing sectors in countries with more open capital markets to foreign investment... the relative factor price of labor to capital, and capital intensity in manufacturing sectors appreciate as windfall increases [and] manufacturing sectors with higher capital intensity are less affected by windfall shocks than their peers, possibly due to a larger share of the effect being absorbed by more labor intensive tradable sectors."

The important policy implication from these findings is that a diversification in capital intensity within manufacturing will assist in cushioning the effects of oil shocks.

2.5.2 Environmental impacts

The impacts on the environment from exploration, drilling and extraction include deforestation, destruction of ecosystems, the contamination of land and water, impacts on animal populations, human health and safety risks to proximate communities and oil workers, as well as the displacement of indigenous people (O'Rourke & Conneley, 2003:594). Accidents and oil spills from the transport of oil, whether by pipeline, tanker, rail or trucks, also have detrimental impacts on the environment. Oil spills from ocean-going vessels affect mainly marine and coastal ecosystems, and some such as mangroves, salt marshes, coral reefs and polar bear habitats are very sensitive (O'Rourke & Conneley, 2003:601). Oil refining has local environmental impacts such as toxic water and air emissions, accidental releases of chemicals and hazardous waste, as well as thermal and noise pollution (O'Rourke & Conneley, 2003:603). The combustion of oil products leads to air and water pollution and the release of greenhouse gases, affecting human health as well.

Effective environmental and health regulations, together with adequate enforcement, are a minimum prerequisite for mitigating the impacts of oil production and use. A further environmental policy option is to reflect the full costs of oil extraction, transport and use in the price of fuels.

2.5.3 Oil price volatility

High dependence on oil revenues

Oil exporters are generally heavily reliant on oil revenues. In Iran, for example, 60% of government and 90% of export revenues are derived from oil (Farzanegan, 2011). The main options for highly dependent oil exporting nations are to strengthen the institutional rules on how to deal with oil revenues and to develop other economic sectors that will help to broaden the tax base. The traditional example of such an institutional rule is to design a fund dedicated to managing revenues and expenditure from oil. Such a fund on its own does not guarantee success. Transparency and professional management is required as well as an assurance that politics will not interfere with "their objective of maximizing the financial wellbeing of the country" (Frankel, 2010:30). Good practice remains to set aside revenues in oil boom times aided by rules governing a cyclically adjusted budget surplus. A prime example of the latter is Chile, who has implemented countercyclical fiscal policies dealing with their copper wealth.

Government revenues and the ability to invest

Oil price and revenue shocks significantly impact government spending behaviour (Eltony & Al-Awadi, 2001). In a study on oil revenue and the Tunisian economy, Jbir and Zouari-Ghorbel (2009) concluded that government spending is the most significant channel by which oil price shocks are transmitted. Farzanegan (2011) further pointed out that negative oil shocks did affect military and security spending in Iran, but not social, education and health efforts. Fiscal policy, therefore, becomes of utmost importance for oil exporters in order "... to smooth surplus export receipts over time, invest them for future growth, and minimize wasteful spending" (AfdB, 2009).

On the question how oil exporters should spend their rents, Gelb and Grasmann (2010) point to a few common factors in countries successful in achieving a positive payoff from resource wealth. The authors concluded that "...[t]hese include a strong concern for social stability and growth, a capable and engaged technocracy, and interests in the non-oil sectors able to act as agents of restraint." They further point out that "...development partners...can help through sharing information, disseminating standards and encouraging civil society, especially constituencies with an interest in spending restraint."

Devarajan *et al* (2011) make the case to directly transfer oil revenues to citizens after which it is taxed to finance public expenditure. The reason for such an approach is that public expenditure efficiencies for oil exporters are generally low when compared with other developing countries. It is further theorized that "...citizens' scrutiny over public expenditure can be increased by transferring oil revenues to citizens and then taxing them." Further, "...[b]y receiving transfers and then paying taxes, citizens are better informed about the level of government revenue, and they have an incentive to ensure that their taxes are spent on public goods." It is further empirically shown that "...enhanced citizens' scrutiny is associated with more efficient government spending decisions and that accountability is stronger in countries that rely more on taxation to finance public spending". The direct transfer of oil revenues to citizens is therefore a mitigation option for oil rich countries to seriously consider. One example is the Alaska Permanent Fund that must distribute half of investment earnings on an equal per capita basis (Frankel, 2010: 32).

Eifert & Gelb (2003) rightly pointed out that a successful management of oil revenues and expenditure depends very much on the type of political regime in any country. The authors conclude:

> "In the end, no single mechanism is likely to provide the ultimate solution: oil-exporting governments will need to use a combination of approaches. They should adopt more cautious, transparent, and flexible budgeting; hedge more; hold larger reserves; and transfer part of the oil earnings to individual citizens during boom periods to reduce pressure for explosive spending followed by lock-in and fiscal crisis during downturns. Some countries are well placed to learn from experience; others, unfortunately, appear to have a long way to go."

2.5.4 Oil depletion

Production peaks

Nashawi *et al* (2009) modelled expected oil peaks for 47 oil producing countries worldwide and concluded that:

> "...world production is estimated to peak in 2014, ...OPEC has...about 78% of the world reserves, ...OPEC production is expected to peak in 2026... [and] ... [o]n the basis of 2005 world crude oil production and current recovery techniques, the world oil reserves are being depleted at an annual rate of 2.1%." (2009: 1788).

Although such models are entirely data driven and "flexible to adjustment whenever additional information becomes available or condition change" (2009: 1798), the results suggest that oil producers, and most urgently non-OPEC countries, will face production limits very soon, or are already facing constraints. According to this model, expected peak production for only Iraq, Kuwait, Saudi Arabia, UAE, and Venezuela is expected to be later than 2025.

It must be noted that peak production estimates are different if estimates derived from reserves and production rates are used. For example, Nigeria, the largest oil producer in Africa, had proved oil reserves of 37.2 billion barrels at the end of 2011, which at a production level of 2.13 million bbl/day in 2011 equates to 48 years of supply if no new oil reserves are found (EIA, 2012b).

As pointed out by Friedrichs (2010) on the basis of historical case material, oil supply disruptions can invoke different types of reactions namely predatory militarism, totalitarian retrenchment or socioeconomic adaptation. In his analysis, however, oil producers are seen to benefit from increasing prices, but questions are raised on the broader socio-economic benefits of such increased revenues. Another hypothesis is that the effect of peak production may change the pattern of oil exports as reserves may be saved for future generations (Aleklett, 2007). The design of a policy on how to manage depleting oil stocks, whether to sell at high prices or leave for future use, is essentially a question of inter-temporal allocation determined by the time preference of the decision-makers.

Domestic consumption

The consensus under peak production scenarios is that the export of oil is expected to fall in oil producing nations, not only due to depletion and (eventually) falling rates of production, but also due to increased domestic oil consumption. In general, the more developed the economy, the higher the oil consumption per unit of GDP and as oil exporters continue their economic development further rising oil consumption can be expected. However, oil exporters are not homogenous, i.e. they have a wide range of oil intensities: countries with more than 80% oil intensity include Yemen, Iraq, Sudan, Timor-Leste, and Chad.

According to Gately *et al*. (2012), OPEC's domestic oil consumption has increased sevenfold in 40 years at an annual rate of 5.1%, compared to income growth of 3.1%. Using an income elasticity of oil demand close to 1, Gately *et al*'s projected figures for growth of oil consumption in OPEC countries are much higher than institutions such as the IEA, U.S. Department of Energy, Exxon-Mobil and OPEC themselves, for Saudi-Arabia even twice as fast (Gately *et al*., 2011).

There is ample evidence for unsaturated growth in domestic consumption for oil exporters, especially in the transport sector, the largest user of refined oil. For around half the oil exporting nations, domestic vehicle use is extremely low: less than 50 passenger vehicles per 1000 people (compared to around 170 per 1000 worldwide). In Saudi Arabia vehicle ownership is at 230 per 1000 or only half the levels in Europe and Japan and 30% of the USA (Gately *et al* 2011).

Even for oil producer nations, therefore, obvious mitigations options would revolve around increased oil use efficiencies and reductions of subsidies in the transport sector. The IEA estimated that fossil-fuel consumption studies worldwide were $409bn, and expected to rise to $600bn in 2020 – 0.7% of GDP (Chazan, 2012). Nigeria had an effective subsidy of $10bn on petroleum in 2011 - a third of its total federal government budget, and this triggered a highly politicised process of reform. Iran also began a programme in 2010 to eliminate subsidies and bring prices to market levels over five years. These examples are only a start though. According to one estimate, "...more than 70 per cent of all direct global oil subsidies are in the world's biggest oil exporting nations, $137bn out of $192bn" (Chazan 2012). With subsidized oil, rapidly rising demand would place additional pressure on depleting stocks in net oil exporting nations.

2.5.5 Corruption and conflict

Civil conflict

The African Development Bank (AfdB, 2009) remarked that social tensions could be fueled by an inequitable distribution of oil revenue among the population, such as what is happening in the Niger delta. It is well-known that the discovery of a new natural resource or the discovery of a greater endowment of a known resource increases the potential for conflict in low-income countries, and more so if the resource that is discovered is oil (Bannon and Collier, 2003).

The evidence of actual civil war in oil producing countries is mixed as several oil-producing nations are peaceful. Basedau and Richter (2011) addressed the question why certain net oil exporters experience civil war and others do not. They concluded that two pathways lead to civil war: "...first, a combination of low abundance and high dependence and, second, a combination of low abundance and the geographical overlap of ethnic exclusion with oil reserve areas within autocracies" (Basedau & Richter 2011: 1). High rents per capita are the surest way for civil war not to occur. A low dependence on oil and a lack of overlap between politically excluded groups and oil-reserve areas also contribute significantly in preventing the onset of civil war (2011: 23). In an earlier study Basedau and Lay (2009) argued that both resource wealth per capita and resource dependence needs to be taken into account when assessing proneness to conflict. They concluded that "...oil-wealthy countries apparently manage to maintain political stability by a combination of large-scale distribution, high spending on the security apparatus and protection by outsiders" (2009: 757).

State fragility

Resource abundance is often associated with low quality of state institutions, such as corruption (Fearon, 2005). Newer research suggests that there is a more nuanced reality. Basedau and Lay (2009: 774) argue that "...oil-wealthy states tend to have better state institutions than their oil-poor counterparts." The explanation lies in higher revenues per capita associated with wealthier states, underscoring the need for an effective distribution of resources to the population. However, as the authors admit, these results do not say anything about the sustainability of authoritarian regimes upholding internal stability, but "...socially undesirable from many other perspectives" (2009: 775). Another caveat is that such stability is not guaranteed once oil runs out or if prices for oil follow a strong downward trend.

A mitigation policy focussed on the large-scale distribution of oil revenues to the broader population, for example via spending on social and economic infrastructure and public services, is a precondition for upholding internal peace and stability in oil exporting nations. In addition, special efforts should be made to strengthen state institutions and implement policies designed to curb corruption related to resource rents.

Relations with foreign oil companies

National oil companies (NOCs) control around 90% of oil reserves globally (Kennedy & Tiede, 2011) and therefore draw a great amount of attention. It is well documented, for example, that Chinese NOCs are investing abroad, but despite allegations that this serves the broader interests of energy security in China, a recent OECD/IEA report found that these expansion efforts "...appear mainly to be driven by commercial incentives to take advantage of available opportunities in the global marketplace" (Jiang and Sinton, 2011:7). These authors point out that despite the fact that Chinese oil companies operate in 31 countries, they have equity shares in only four: Sudan, Angola, Kazakhstan and Venezuela.

The urge to nationalize to secure the oil rents for oil producing states is back on many oil producing countries' agendas. Venezuela, Bolivia, Chad, Ecuador and the Russian Federation are all recent cases in point. Guriev *et al* (2009), having studied nationalizations in the oil industry from 1960-2006 concluded that "...nationalization is more likely to happen when oil prices are high and the quality of institutions is low...". Kennedy & Tiede (2011) rather point towards political factors that lead to nationalization, most notably the importance of resources in the broader economy, the role of policy entrepreneurs and a change in regimes. One risk attached to nationalization is that it may limit the amount of foreign capital and technological expertise that may be required to fully exploit an oil exporting country's oil reserves, especially if they are located in technically more challenging geological formations, such as heavy oil deposits or deep offshore fields. A balance has therefore to be struck between ensuring sufficient domestic control over oil resources versus the ability to exploit those resources effectively.

Strong institutional and legal structures are needed to ensure an equitable share of oil revenues with foreign oil companies, an observation that is especially relevant to small and new oil exporting countries, and also especially relevant in a context of rising oil prices and thus revenue for net oil exporters. Ghana for example, has a strategy that makes it relatively easily for foreign investors to enter. They have sold extraction rights to foreign companies, but do retain some control to the state, capturing royalties and taxes paid for by the oil companies (Steffenson *et al* 2011).

2.5.6 Summary and conclusions

A summary of issues and options for mitigation of oil shocks for oil exporters is contained in Table 2-4.

Table 2-4: Mitigation issues and options for oil exporting countries

THEME	MITIGATION OPTIONS
Exchange rates	■ There is a high risk that efforts to counter appreciating exchange rates are misplaced and counter-productive for oil exporters. ■ Without flexible exchange rates, money supply and inflation have started increasing in most oil exporting nations. ■ Long-term growth is positively associated with increasing oil income from oil exports.
Foreign reserves	■ The opportunity costs of holding large reserves tends to be high as returns in high grade-low risk instruments are low, placing increasing pressure on oil exporter governments to invest in the local economy. This raises the importance of an effective fiscal policy.
Diversification	■ Effective diversification of resource-rich countries can be achieved if there is macroeconomic stability underpinned by prudent spending, a reasonably open trade policy, and the active use of resource rents to increase the productivity of other exportable sectors. ■ A diversification in capital intensity within manufacturing will assist in cushioning the effects of oil shocks.
Environmental impacts	■ Effective environmental and health regulations, and adequate enforcement are a minimum prerequisite for mitigating the impacts of oil production. ■ A further environmental policy option is to reflect the full costs of oil extraction, transport and use in the price of fuels.
High dependence on oil exports	■ The main option for highly dependent oil exporting nations is to strengthen the institutional rules on how to deal with oil revenues and to develop other economic sectors that will help to broaden the tax base.
Government expenditure	■ Fiscal policy is of utmost importance for oil exporters in order to smooth surplus export receipts over time, invest them for future growth, and minimize wasteful spending. ■ Success factors include a strong concern for social stability and growth, a capable and engaged technocracy, and interests in the non-oil sectors able to act as agents of restraint. ■ The direct transfer of oil revenues to citizens is a mitigation option for oil rich countries to seriously consider.
Oil production and consumption	■ Governments should conduct thorough oil resource and reserve assessments and attempt to generate realistic forecasts of future oil production to serve as a rational basis for long-term economic planning and policies. ■ Mitigations options for dealing with rising domestic oil consumption would revolve around increased oil use efficiencies and reductions of fuel subsidies, especially in the transport sector.
Civil conflict	■ A mitigation policy focussed on the large-scale redistribution of oil revenues to the broader population, for example via spending on economic infrastructure and social services, is a precondition for upholding internal peace and stability in oil exporting nations.
Foreign investment	■ Strong institutional and legal structures are needed to ensure an equitable sharing of oil revenues with foreign oil companies, an observation that is especially relevant to small and new oil exporting countries, and also especially relevant in a context of rising oil prices and thus revenue for net oil exporters.

part 3.

CONCLUSIONS

3. CONCLUSIONS

Since the mid-18th century, the process of industrialisation has been powered largely by fossil fuels: first coal, then oil, and more recently by natural gas. Oil has been the world's predominant source of energy for over half a century and today still accounts for a third of global primary energy supply and 40% of final energy consumption. Transport systems in particular are overwhelmingly reliant on oil, while petrochemicals serve as feedstock for a myriad of consumer products. Yet the world's reliance on oil entails considerable risk. In the short term, threats to global oil supplies are posed inter alia by geopolitical and civil tensions in oil exporting regions and countries, by certain technical production complexities, and by extreme weather events. In the long run, oil supplies will grow ever scarcer as this finite source of energy continues to deplete. This growing scarcity is evident in the persistently high price of oil, which has been trading in triple digits for several years despite the lingering after-effects of the Global Financial Crisis. A consensus is emerging that the age of cheap and abundant oil is over for good, and there is a heightened risk of major oil price spikes, which historically have had adverse economic and social impacts on net oil importing countries and sometimes destabilising impacts on oil exporting nations. Developing countries are especially vulnerable to oil shocks as many have a relatively high oil intensity of economic growth, while the least developed countries often lack the resources to cope effectively with external economic shocks. The International Energy Agency advises its high-income member countries on appropriate responses to oil shocks and coordinates their actions, but no similar agency or set of mitigation plans exist for developing countries.

Against this backdrop, the aims of this report were firstly, to develop a framework for analysing country-level oil dependencies and vulnerabilities to oil price and supply shocks, and secondly to provide a generic set of mitigation strategies that can be refined according to country-specific circumstances and conditions. As an analytical framework intended to enhance tractability, developing countries were divided into four categories, namely: low income oil importing countries, lower middle income oil importing countries, upper middle income oil importing countries, and oil exporting countries.

3.1 Oil shock vulnerabilities and impacts

The investigation of oil dependencies and vulnerabilities identified certain similarities within each of the four generic categories. Low income countries are for the most part only just embarking on the transition from agrarian to industrial modes of subsistence, and therefore their use of oil products is very limited. However, most of these countries are highly constrained in terms of their economic and human resources and the strength of their institutions, which renders them particularly vulnerable to external shocks, including those driven by oil price spikes. Lower middle income countries have mixed techno-economic bases and while they share many of the vulnerabilities of their poorer counterparts, they tend to be more energy intensive overall but have somewhat more economic flexibility. Upper middle income countries are more heavily invested in oil-dependent infrastructure and settlement patterns, but have greater technical and financial capacity to adapt to rising oil prices. All net oil importing developing countries face similar economic impacts arising from global oil price shocks, such as: rising oil import bill and deteriorating balance of payments; rising rates of producer and consumer price inflation; slowing down of economic growth; and rising costs of living, deepening poverty and possibly inequality.

Despite the generalisations made above, one of the key findings stemming from the empirical analysis is that there is a high degree of heterogeneity amongst the countries in each of the four generic categories, both in terms of their vulnerability profiles and their capacities to respond to oil shocks. Therefore, each country will need to assess its particular strengths, weaknesses and oil shock vulnerabilities given its distinctive characteristics. This report has presented a methodology and framework for identifying such vulnerabilities on a case-by-case basis. Vulnerabilities can assessed on spatial scales (regional, national and local), on a sectoral basis (e.g. energy, transport systems, agriculture and food security, macroeconomic stability, social cohesion), and according to the impact on vulnerable social groups (e.g. poor households and those experiencing food insecurity). Among the most vulnerable countries are those that are heavily reliant on oil imports, those that have highly oil-intensive economies, those that rely heavily on oil for electricity generation, landlocked countries, Small Island Developing States, fragile states, and economically poor countries.

The on-going depletion of relatively easily accessible and cheap oil reserves suggests that the rising trend in real oil prices observed over the past decade may well continue (albeit with heightened short-term price volatility). This clearly has significant implications for developing countries. For net oil importing nations, rising oil costs implies that the poorer countries may never to be able to afford the oil-intensive pattern of development that has been pursued by the industrialised and semi-industrialised world, while the semi-developed nations could find their current oil-based industrialisation path interrupted by shocks and increasingly unviable. For net oil exporting developing countries, rising average global oil costs will translate into windfall revenues as long as their rates of production and exports can be maintained, but face the prospect of greater oil price and revenue volatility in the medium term and declining net exports in the longer term. The challenge for these countries is to build strong institutions and to use their oil revenues for sustainable and equitable long-term development.

3.2 Mitigation strategies

Given the extensive socioeconomic threats posed by oil price and supply shocks, and the uncertainty surrounding these, there is a strong pragmatic rationale for the design and implementation of proactive, government-led mitigation strategies. The mitigation strategies described in this report (especially for oil importing countries) essentially fall into two categories.

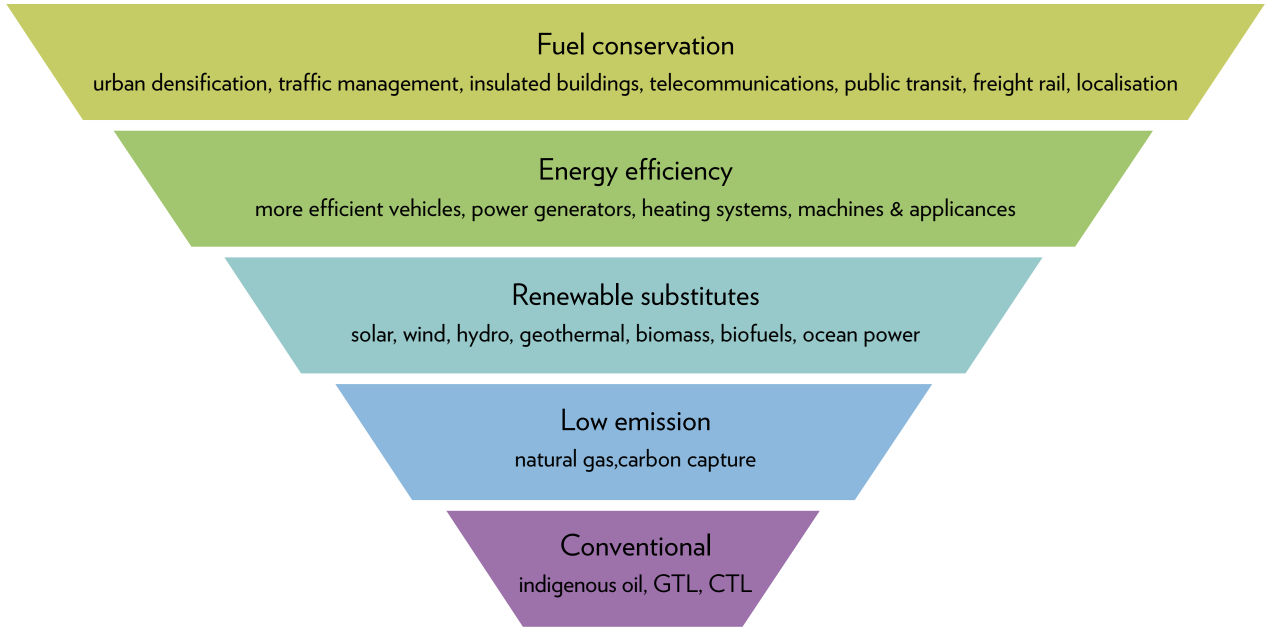
The first set of strategies is intended to **build resilience to short-term oil shocks.** Specific measures include introducing *redundancies*, such as back-up energy systems, strategic fuel inventories, and increased foreign exchange reserves, in order to provide enhanced *resourcefulness* and shock absorption capabilities. The *responsiveness* of countries to shocks, in terms of the ability of the state to mobilise effectively, depends on the availability of existing emergency response plans (including, for example, fuel price stabilisation mechanisms and fuel rationing schemes) as well as effective communication with the citizenry (e.g. explaining the need for and benefits of emergency measures). *Regional self-reliance* can be enhanced through cooperative agreements among neighbouring countries, in terms of for instance the pooling of regional energy resources and the formation of oil and food security funds. Measures that are designed to protect the most vulnerable sectors of society will help to ensure recovery after exogenous shocks through stabilisation and adaptation. These various resilience measures are summarised in Figure 3-1 opposite.

Figure 3-1: Measures to promote resilience to oil shocks

Redundancies	• strategic fuel inventories • back-up energy systems • alternative oil suppliers
Resourcefulness	• increase foreign exchange reserves • reduce foreign & domestic debt & public deficits • increase food stocks
Responsiveness	• fuel price stabilisation mechanisms • emergency response plans, including fuel rationing schemes • public awareness campaign, including eco-driving; traffic management
Regional self-reliance	• oil depletion protocol • regional oil & food security funds • pooling of regional energy resources
Recovery	• social protection schemes • effective fiscal & monetary policy responses to inflation & exchange rate volatility

The second class of strategies aim to achieve a **long-term societal transition** toward a more sustainable socio-metabolic regime powered by renewable energy sources and characterised by much higher levels of resource efficiency and productivity. As such, long-term mitigation of (cumulative) oil shocks provides a strong rationale for "green growth" strategies, over-and-above the usual (often climate-related) motivations. This involves planning for a gradual decoupling of socioeconomic development from oil consumption in particular and from energy and resource consumption in general. In particular, it implies reducing dependence on imported oil through measures that boost energy efficiency and conservation, and develop a locally-appropriate and sufficiently diverse mix of indigenous substitutes for oil. Transport systems need to undergo a fundamental revolution, in which vehicles powered by internal combustion engines progressively give way to electrified transport modes that offer much greater energy efficiencies as well as reduced reliance on oil. Reducing exposure to oil shocks also requires a reorientation of the economy away from dependence on global trade networks and toward greater regional economic cooperation, self-reliance, diversification and relocalisation of economic activities. This is of particular importance in the area of food sovereignty and food security, since oil is a key input in global agriculture and spiking oil prices are commonly associated with rapidly rising food prices. Human settlements need to be designed around people instead of cars, allowing a more efficient mix of activities within urban areas so as to reduce the structural requirements for motorised mobility. Figure 3-2 arranges the main long-term mitigation measures in a sustainability hierarchy.

Figure 3-2: Hierarchy of sustainable long-term mitigation measures



SOURCE: Adapted from Wolf (2005)

Because of constraints on economic, material and human resources, each country will need to find an appropriate balance between investments in short-term responses that attempt to improve the robustness of the oil-based status quo, versus those that are aimed at a more fundamental restructuring of energy and transport systems. For example, countries that invest in oil storage facilities may have fewer funds available for expanding electricity grids and public transport infrastructure.

Developing countries face the prospect of exploiting new opportunities that will arise as oil and other fossil fuels continue to become more costly as a result of long-term depletion and growing demand, and as the need to reflect the true social and environmental costs of fossil fuels in their prices grows. Most importantly, they can aim to (partially) leapfrog the oil-intensive development path taken by the industrialised countries by investing in decentralised, renewable energy systems and more efficient transport systems, and by taking a less transport-intensive pathway through better spatial planning that prioritises non-motorised forms of mobility.

3.3 Issues for further research

It is clear from this report that oil shocks have wide-ranging impacts across numerous sectors of the economy and society. The research contained in this report could however be extended both in depth and in breadth. In terms of depth, an investigation of oil shock vulnerabilities, impacts and mitigation could be taken to a greater level of detail on a regional basis as well as for individual countries. The four case studies undertaken as part of this project serve as examples of a deeper exploration of oil dependencies and vulnerabilities, and this methodology could be applied to other countries. Furthermore, the high level of variability amongst countries – even those within the same income category – means that mitigation strategies really need to be tailored according to the specific conditions pertaining in any particular country. For example, cost-benefit analysis of the various mitigation options needs to be undertaken at a country-specific level.

The scope of analysis could also be broadened in follow-up studies to include issues such as:

- an analysis of vulnerabilities and mitigation for important sectors of the economy not elaborated upon in this report, such as mining, manufacturing, construction and tourism, all of which tend to rely fairly heavily on oil products;
- other potential social impacts of oil shocks, for instance on public health (e.g. see Neff et al., 2011; Winch and Stepnitz, 2011);
- links between oil shock impacts and mitigation strategies on the one hand, and on the other hand policies designed to preserve the environment and resources, including mitigation of and adaptation to climate change and responding to other key resource constraints (e.g. water and scarce minerals);
- the implications of oil shocks for domestic political stability and governance; and
- geopolitical aspects of oil shocks, including regional relations and potential conflict, as well as the influence of major powers such as the US and China.

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APPENDIX

5.1 Determinants of oil consumption

Table 5-1 presents the results of ordinary least squares regression analysis performed using EViews econometric software on a combined sample of net oil importing countries (including LICs, LMICs and UMICs). After adjusting for missing data, there were 58 observations (countries) included in the regression. The first four independent variables are all statistically significant at the 5% level (in each case the "Prob." value – namely the probability that the t-Statistic is insignificant – is less than 0.05). However the last three variables are not statistically significant at the 5% level. The Adjusted R-squared shows that 66% of the variation in the dependent variable (oil consumption) is explained by the group of independent variables. The negative coefficient on the FUEL_PRICE variable is expected, as the higher fuel prices should result in lower fuel consumption, all else being equal.

Variable names:
- OIL_USE = barrels of oil consumption per capita (2011)
- INCOME =gross national income per capita (2011)
- FUEL_PRICE = average of diesel and petrol pump price (2010)
- VEHICLES = motor vehicles per 1,000 people (2009)
- ELEC_OIL = percentage of electricity generated from oil (2009)
- OIL_IMPORTS = oil imports as a percentage of total oil consumption (2011)
- INDUSTRY = industry value added as a percentage of gross domestic product (2010)
- URBANISATION = percentage of population living in urban areas (2010)

Table 5-1: Statistical regression analysis: determinants of oil consumption per capita

Dependent Variable: OIL_USE **Method: Least Squares** **Sample (adjusted): 2 105** **Included observations: 58 after adjustments**				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.869745	1.605662	0.541674	0.5904
INCOME	0.000289	0.000123	2.353662	0.0226
FUEL_PRICE	-2.093209	0.798248	-2.622254	0.0115
VEHICLES	0.009704	0.002963	3.275313	0.0019
ELEC_OIL	0.018327	0.007817	2.344655	0.0231
OIL_IMPORTS	0.009840	0.007791	1.262971	0.2125
INDUSTRY	-0.006214	0.029194	-0.212859	0.8323
URBANISATION	0.026747	0.016418	1.629161	0.1096
R-squared	0.700288	Mean dependent var		3.241379
Adjusted R-squared	0.658328	S.D. dependent var		2.629324
S.E. of regression	1.536911	Akaike info criterion		3.824868
Sum squared resid	118.1048	Schwarz criterion		4.109067
Log likelihood	-102.9212	F-statistic		16.68953
Durbin-Watson stat	1.658986	Prob(F-statistic)		0.000000

Table 5-2 below shows the results of the regression which includes only the statistically significant explanatory variables. The Adjusted R-squared shows that 65% of the variation in the dependent variable (oil consumption) is explained by the four statistically significant independent variables.

Table 5-2: Statistically significant determinants of oil consumption per capita

Dependent Variable: OIL_USE				
Method: Least Squares				
Sample (adjusted): 2 105				
Included observations: 59 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.325099	0.823708	2.822721	0.0067
INCOME	0.000376	9.90E-05	3.801246	0.0004
FUEL_PRICE	-1.977060	0.733528	-2.695277	0.0094
VEHICLES	0.010068	0.002976	3.382964	0.0013
ELEC_OIL	0.018230	0.007204	2.530635	0.0143
R-squared	0.673482	Mean dependent var		3.205085
Adjusted R-squared	0.649296	S.D. dependent var		2.621425
S.E. of regression	1.552415	Akaike info criterion		3.798439
Sum squared resid	130.1397	Schwarz criterion		3.974502
Log likelihood	-107.0540	F-statistic		27.84539
Durbin-Watson stat	1.608807	Prob(F-statistic)		0.000000