



Rupees.
Image: Addison Berry.



Chapter 7
The Economy



Chapter 7.1

Economy | Economic output and the government

Summary of economic output indicators

Indicator		Tropics	Central & Southern Africa	Northern Africa & Middle East	South Asia	South East Asia	Caribbean	Central America	South America	Oceania	Rest of the World	World
Economic output (1980-2010)	Average annual growth	2.1%	0.6%	-0.5%	4.6%	4.3%	1.8%	0.5%	0.8%	1.2%	2.0%	1.8%
	GDP per capita*	2,480-4,680	1,310-1,590	4,060-3,460	950-3,670	1,620-5,680	5,670-9,730	8,240-9,700	7,220-9,260	8,890-12,530	7,720-13,800	5,710-9,840
Public sector debt service (1980-2010) (% of GNI)		3.3-1.1	4.1-1	2.8-1	0.7-0.5	1.8-1.1	2.5-2.0	4.2-1.9	3.9-1.1	N/A	N/A	N/A

*Measured at purchasing power parity in constant 2005 international dollars.

The past 60 years has seen a dramatic rise in living standards across the world. Even nations that today are relatively poor enjoy living standards that were unprecedented 100 years ago. The reasons for this development are varied and complex, however economic growth is considered the most useful indicator for improvements in living standards. Nations that have strong economic growth are better able to reduce poverty rates, strengthen political stability, improve the quality of the natural environment and even diminish the incidence of crime and violence.

Government refers to the system by which a nation, state, or community is governed. It sets and administers public policy and exercises executive, political and sovereign power through customs, institutions, and laws. Decisions made by governments determine how public money is spent, invested and borrowed. Therefore,

governments are often directly responsible for facilitating, encouraging and sometimes impeding progress in communities, states or nations.

Headline indicator

Gross domestic product per capita

An economy consists of labour, capital and land resources that produce the goods and services a society consumes. When economic growth is achieved through the more productive use of all resources – including labour – it results in higher per capita income and an improvement in average living standards. Increased productivity is important to economic development.

Supplementary indicator

Public sector debt burden

Public sector debt and deficits concern governments throughout the world. All nations have some form of public debt, but it is the

ability to pay that debt that indicates whether it is sustainable or not. Total debt service is the sum of principal repayments and interest actually paid in foreign currency, goods, or services on long-term debt, interest paid on short-term debt and repayments (repurchases and charges) to the International Monetary Fund (IMF) and other creditors. Data are public and publicly guaranteed debt service as a percentage of gross national income (GNI).

Links to other dimensions

Gross capital formation, imports and exports, foreign direct investment.

Is it getting better?

Economic output:

Economic growth in the Tropics has outperformed the Rest of the World over the past 30 years. The Tropics is now estimated to represent 18.7% of global economic activity, up from 14.5% in 1980. South East Asia and South Asia have driven this increase with these two regions representing 10.3% of all global economic output, up from 4.6% in 1980. Despite this, GDP per capita in the Tropics was estimated to be only one-third that of the Rest of the World in 2010. Growth rates in Africa and South America have improved significantly over the past ten years, influenced by stronger demand for commodities, greater political stability and improved governance.

Public debt:

Public sector debt service burden has been improving across most regions of the Tropics over the past three decades. The debt service burden declined in the Tropics by two thirds (from ~3% of GNI to 1% of GNI) between 1980 and 2010.

Since the late 20th century, there has been a strong focus by the international community on reducing debt burdens in the world's poorest nations. Continuing to manage this debt into the future will be a challenge for all nations but particularly for highly indebted nations in the Tropics with unstable governments and shallow export bases.



Waterloo Street, Singapore. Image: William Cho.

Economic output

Across the world there are striking variations in living standards between the richest and the poorest nations. Nonetheless, for most of the world the past 60 years has seen rapid rise in living standards, and even nations that today are relatively poor enjoy living standards that were unprecedented 100 years ago (Weil 2009).

The interplay of environmental, social and economic factors determines living standards. It is generally agreed that important factors for improvements include urbanisation, industrialisation, opportunities for non-agrarian employment, improved education and health care, participation in the global economy and effective governance frameworks. Differences between and within nations with respect to the rate of progress in these variables will affect changes in living standards over time (Sinding 2009). As there is no composite measure that reliably reports each factor's contribution to living standards, economic activity and the income that it generates is generally accepted as a proxy measure of living standards.

The role of economic growth in contributing to improved living standards cannot be overstated as it is necessary – though not sufficient – for achieving social development. Nations that have strong economic growth are better able to reduce poverty rates, strengthen political stability, improve the quality of the natural environment and even diminish the incidence of crime and violence (Loayza & Soto 2002). Economic growth can also provide the resources for public programs that complement its benefits and correct its deficiencies, even if its direct beneficial impact to individuals is modest.

Economic activity is measured as the value of goods and services produced in an economy, and is influenced by a nation's resource endowment, supply of physical and human capital, and demand for the goods and services that it produces. Economic activity occurs in short term cycles which generate year-to-year fluctuations, but it is the long term trend of economic growth that determines how rich a nation is. Gross domestic product (GDP) is the most common

measure of aggregate economic activity (see Box 7.1).

A large range of economic and social variables influence long term growth rates, including structural policies and institutions, political stability and external conditions. For example, industry and tax policies that create stable macroeconomic conditions are important for growth, while high and variable inflation constrains investment, and excessive tax burdens can distort efficient resource allocation. Institutional structures and policies that favour competition and flexibility in capital, labour and product markets and encourage innovation have a major impact on growth prospects, as do financial systems that direct capital to projects with the highest returns. Investment in physical and non-physical capital (such as education) is also critical for sustained economic growth (OECD 2003).

The interplay of each of these variables impacts productivity, which is a major factor influencing differences in economic growth rates across nations. Sustained productivity and economic growth is typically associated with higher real income, employment and living standards. When measured on a per capita basis GDP is recognised as a general indicator of personal income, and as a proxy for a nation's living standards.

Nonetheless, as the importance of long term environmental and social impacts of economic growth are being increasingly realised, more comprehensive measures of well-being have been developed¹. However, the majority of these measures are still narrow in their perspective, only incorporating a small number of indicators. While useful for comparative purposes, the reality is that a broad range of other indicators also need to be assessed when considering societal well-being and progress.

¹These include the United Nation's Human Development Indices and Yale University's Environmental Performance Index.

Trends

Gross domestic product

Global GDP measured at constant value purchasing power parity (PPP), increased at an average rate of 3.4% per annum in the 30 years to 2010. In the Tropics growth is estimated to have averaged 4.1% per annum over the same period, well above 3.2% growth per annum in the Rest of the World. Figure 7.1.1 shows that except for in the early 1980's and late 1990's, annual economic growth in the Tropics has outperformed the Rest of the World over the past 30 years.

Nonetheless, the performance of the regions of the Tropics has varied markedly (see Table 7.1.1). The evolving story in the Tropics (and the World) over the past 30 years is the emergence of South Asia and South East Asia as powerful economic regions. In 2010 these two regions accounted for 55% of economic output in the Tropics, up from 31% in 1980, and have accounted for close to 65% of economic growth in the Tropics in the 30 years to 2010. Central & Southern Africa, the Caribbean and South America also report solid growth, especially in the past 15 years. Growth rates in most other regions of the Tropics were below that of the Rest of the World in the 30 years to 2010, with Northern Africa & Middle East and Central and South America reporting the weakest growth.

Table 7.1.1 also shows a distinct shift in economic growth patterns over the past ten years. While the rate of growth is strengthening in most tropical regions, it has been deteriorating in the Rest of the World. The impact of the global financial crisis was a major factor in the Rest of the World's performance in the five years to 2010, though growth had already weakened substantially prior to that.

While South East Asia and South Asia reported consistently strong growth over the past 30 years, most other tropical regions, with the exception of Oceania, have endured periods of relatively weak growth through the 1980s and 1990s. This has changed dramatically in the past ten years, with the stronger performance reported in most tropical regions typically associated with

Box 7.1.1 Gross domestic product

GDP is the total value of goods and services produced in an economy after deducting the cost of resources used in the production process. GDP is a fairly comprehensive measure of economic activity, but does not account for consumption of capital in the production process (including the depletion or degradation of natural resources) and non-market activities such as unpaid household work.

GDP is a useful indicator as it condenses the complexity of national economic activity to a single number. Other benefits of GDP as a measure of economic activity are that a relatively standard definition is used by all nations, it is reported frequently, and some measure of GDP is available for almost every nation. As such, international comparisons are relatively easy and trends can be identified quickly.

GDP is reported in local currency units and can readily be converted to other units (such as US or international dollars) to facilitate international comparisons on a consistent basis. Controlling for price changes also allows for more reliable comparison of changes in economic activity over time. When price changes are controlled, data are referred to as being in 'chain volume', 'constant price' or 'real' terms.

A key point to note is that GDP is a measure of economic activity, not a measure of living standards – two quite separate concepts. The argument for using GDP as a proxy indicator of living standards or personal income is not that it is a good measure of the absolute level of living standards, but that living standards tend to change with per-capita GDP.



Mining truck. Image: Graeme Churchard.

government reforms coupled with improving commodity prices.

Solid economic growth in South East Asia and South Asia was reported across most nations, but in absolute terms has been dominated by the sheer size of the Chinese and Indian economies, and their very strong and sustained growth performance even though only tropical regions of these nations are included in the analysis.

In China, economic reforms commenced in the late 1970s have generated significant and consistent growth in investment and consumption, and China now participates extensively in world markets. In India, trade and economic reforms introduced since the mid 1980s have significantly increased its global competitiveness and contributed to a rapid expansion of the services sector.

Stronger economic growth in the Tropics has seen its proportion of global GDP increase from 14.5% in 1980 to 18.7% in 2010. Even globally the rise of South East Asia and South Asia is significant. In 2010 these two regions of the Tropics accounted for 10.3% of global economic output, up from 4.6% in 1980 (see Figure 7.1.2), and their significance to global economic activity has been accelerating in recent years. The two regions accounted for 13.8% of global economic growth in the 30 years to 2010, and their contribution to growth has increased in the past 10 to 15 years. In the 10 years to 2010 South East Asia and South Asia accounted for 17.1% of global economic growth.

Of note, Central and South America's proportion of global economic activity has fallen markedly over the past 30 years (see Figure 7.1.2). Weaker growth was particularly evident between 1980 and 2000. In Central America this reflected Mexico's 1982 debt crisis and 1995 financial crisis and, in South America, generally high political and economic risks and inflation. Growth rates in both regions have improved over the past ten years, supported by political stability in many countries, market-oriented reforms, trade liberalisation and, particularly in South America, strong global demand for commodities.

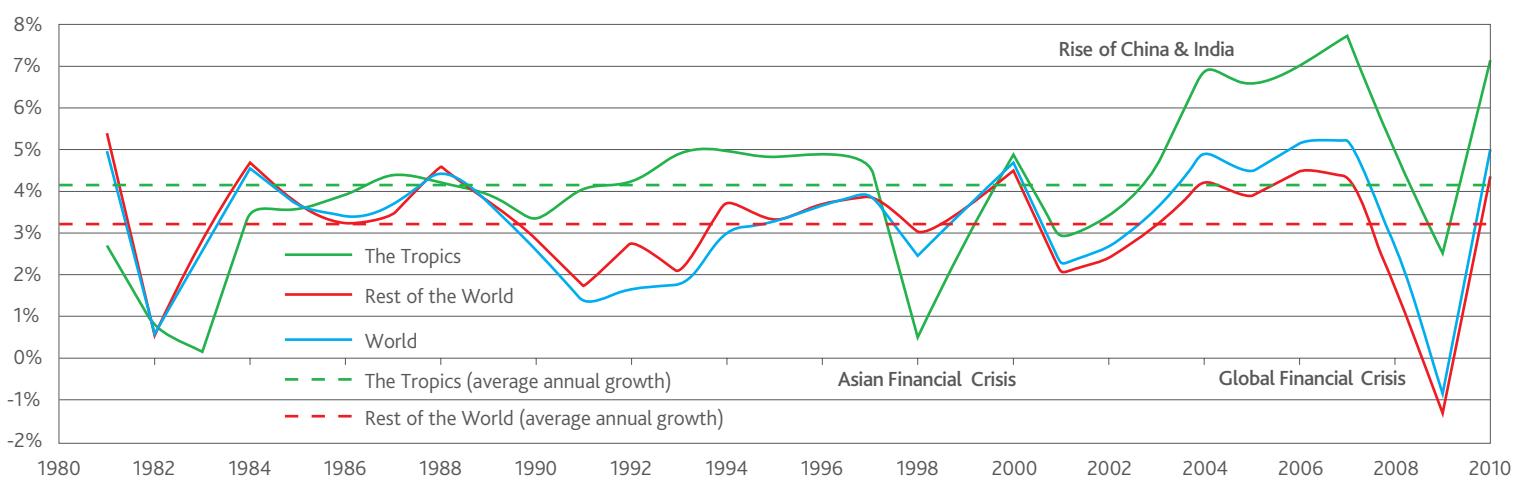
Table 7.1.1 Economic growth*

	Average annual growth (%)							
	1980 - 1985	1985 - 1990	1990 - 1995	1995 - 2000	2000 - 2005	2005 - 2010	1980 - 2010	2000 - 2010
Tropics	2.1	3.9	4.6	3.6	4.8	5.8	4.1	5.3
Central & Southern Africa	0.9	3.3	1.1	3.8	5.5	6.5	3.5	5.9
Northern Africa & Middle East	-3.2	3.4	2.6	3.3	4.3	3.6	2.3	3.9
South Asia	4.9	5.7	5.9	5.6	7.1	8.3	6.3	7.7
South East Asia	4.5	7.5	8.2	3.4	6.1	6.5	6.0	6.3
Caribbean	0.3	2.3	3.7	4.7	4.0	4.6	3.3	4.0
Central America	1.7	1.4	1.5	4.9	1.8	2.6	2.3	2.2
South America	0.9	2.1	3.3	1.7	3.1	4.5	2.6	3.8
Oceania	4.1	3.7	3.2	3.9	3.3	2.1	3.4	2.7
Rest of the World	3.4	3.6	2.7	3.7	3.1	2.7	3.2	3.1
World	3.2	3.6	3.0	3.7	3.4	3.3	3.4	3.4

Source: World Bank (2013) State of the Tropics project.

*Gross domestic product measured at purchasing power parity in constant 2005 international dollars.

Figure 7.1.1 Economic growth*



Source: World Bank (2013), State of the Tropics project.

Per capita gross domestic product

With the exception of Northern Africa & Middle East, all regions in the Tropics reported growth in GDP per capita in the 30 years to 2010 (see Table 7.1.2). Starting from the lowest base, South Asia reported the fastest growth in per capita GDP, increasing at an average rate of 4.6% per annum, followed by South East Asia which increased at 4.3% per annum.

When population growth exceeds economic growth, deterioration in GDP per capita and general living standards is implied. This is what has occurred in Northern Africa & the Middle East, where population growth averaged 2.8% per annum in the 30 years to 2010, and economic growth 2.3% per annum. Over the past decade stronger economic growth has driven improvements in GDP per capita, as population growth has remained relatively high, averaging 2.9% per annum.

Living standards and demography

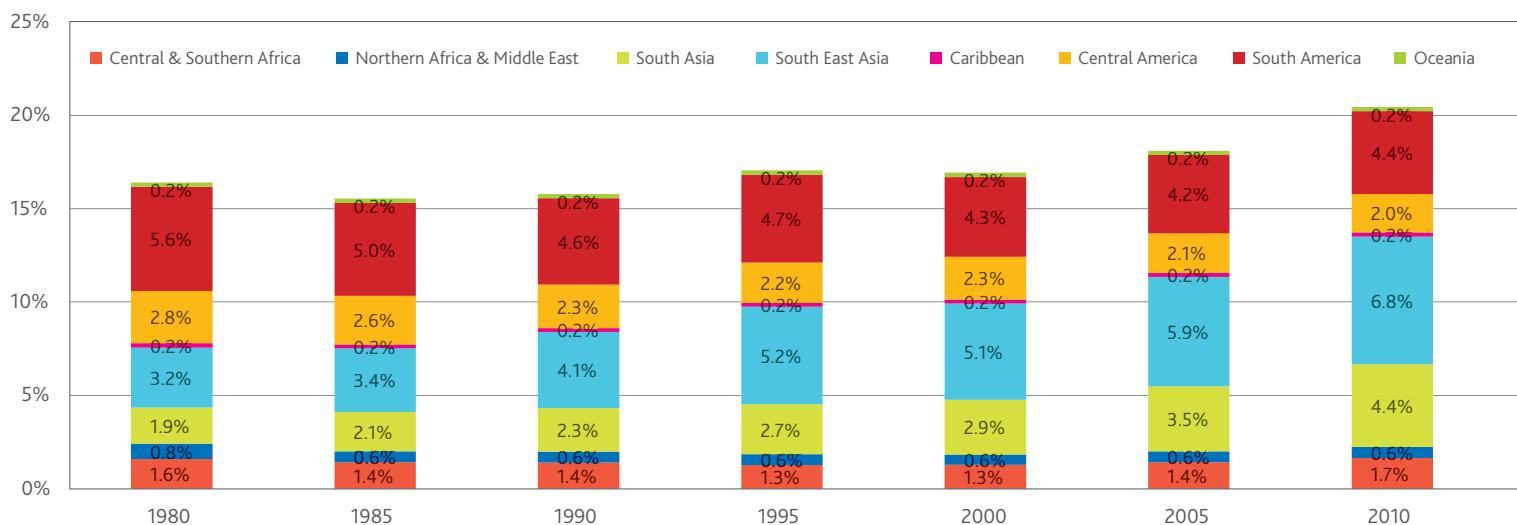
As population growth is primarily a function of fertility and mortality rates², GDP per capita is influenced by changes in these variables. That is, changes in living standards are a function of economic growth, but also of demographic change. Globally, fertility rates have declined over the past 60 years – from 4.97 in 1950 to 2.53 in 2010 – and in the developing world, declining birth rates and rising living standards have tended to go hand-in-hand. In the Tropics the absolute decline in fertility rates is even more dramatic than globally, down from 6.15 in 1950 to 3.35 in 2010 (see Table 7.1.3). Working in the opposite direction, life expectancy has increased markedly over the past 60 years, but its impact in terms of population growth is less significant.

Reductions in fertility contribute to changes in the structure of the population, increasing the size of the workforce relative to the number of children under the age of 15 and people over 65 (that is,

the 'dependent' population). When fertility is high and a nation is 'young' there are a large number of dependent children in society. Similarly, as a population ages, the dependency ratio increases, as older people leave the workforce. But the switch from one to the other provides a window for economic development and poverty reduction – the so-called demographic dividend – as the twin impacts of an increase in the economically active population and a decrease in the dependent population increases income per capita outcomes.

² Figures for 'The Tropics' and 'Rest of the World' use nations for which the World Bank reports a minimum of 25 years of data (i.e. at least 80% of data points). 'World' figures are reported by the World Bank. For 2010 'The Tropics' and 'Rest of the World' represent 91.4% of world GDP. Nations excluded from the analysis include the Russian Federation (3.0% of the World Bank's global PPP in 2010), Poland and Taiwan (around 1% each), Ukraine (0.4%) and Czech Republic (0.4%). Nations in the Tropics that are excluded represented around 0.5% of global GDP in 2010, and include Cuba, Puerto Rico, Tanzania, Somalia and Zimbabwe. In the 30 years to 2010 the World Bank reports average global PPP GDP growth of 3.3% per annum, while the State of the Tropics abridged series estimates growth of 3.4% per annum.

Figure 7.1.2 The Tropics – proportion of global economic activity*



Source: World Bank (2013), State of the Tropics project

* Gross domestic product measured at purchasing power parity in constant 2005 international dollars

Rapid economic growth in South East Asia and Latin America has been attributed to this dividend, and more recently the growth of the working age population in South Asia has also had a positive impact on economic growth (Aiyar & Mody 2011). Although life expectancy throughout Africa and the Middle East has improved, this region has yet to experience the much lower fertility of other tropical regions, potentially slowing demographic transition (Bloom et al. 2003).

This is not to suggest that lower fertility is a necessary condition for economic development but, intuitively, lower fertility establishes conditions in which families and governments can invest more per capita in education and health, and in developing the human capital needed for sustained economic growth (Sinding 2009). In the Tropics the pace of decline in fertility rates has been particularly pronounced over the past 30 years.

Figure 7.1.3 plots GDP per capita and fertility rates for the Tropics in 2010 and shows the strong link between the two. Nonetheless declining fertility alone is not sufficient to ensure the demographic dividend translates to stronger economic growth and rising living standards. There is a need for these demographic changes to be complemented by sound policies that support economic growth. Traditionally this has been around factors such as governance, savings, investment, industry, fiscal and monetary policies and trade openness, but is now also increasingly cast in terms of the need to invest in human capital and development to sustain economic growth and improve living standards.

A key issue in economic development is whether economies that start out behind in terms of income per capita tend to grow faster and converge towards those that began ahead. Research around this concept is inconclusive, but

it appears likely that convergence is constrained because of the imperfect mobility of factors of production (notably labour); different endowments (notably human capital); market segmentation (especially for services); and limited technology diffusion (especially related to distance, but also in applying technology developed in the temperate zone to tropical settings) (Sachs 2001). However general policy shifts towards greater deregulation of capital, labour and product markets in developing markets, are supporting growth and convergence. Nations will have different long run GDP per capita outcomes because of differences in government policies (e.g. taxation, property rights, infrastructure provision and services etc), social attitudes (e.g. saving, work effort, fertility etc.) and natural resource endowment.

Even if convergence does not occur it is important for tropical nations to pursue economic

Table 7.1.2 GDP per capita*

	1980	1985	1990	1995	2000	2005	2010	1980 to 2010 (average annual growth %)
Tropics	2,480	2,450	2,660	3,010	3,270	3,810	4,680	2.1%
Central & Southern Africa	1,310	1,180	1,200	1,100	1,160	1,330	1,590	0.6%
Northern Africa & Middle East	4,060	2,700	2,710	2,810	3,040	3,220	3,460	-0.5%
South Asia	950	1,100	1,310	1,630	1,970	2,630	3,670	4.6%
South East Asia	1,620	1,830	2,390	3,160	3,490	4,350	5,680	4.3%
Caribbean	5,670	5,240	5,450	6,060	7,130	8,180	9,730	1.8%
Central America	8,240	8,070	7,780	7,660	8,930	9,140	9,700	0.5%
South America	7,220	6,680	6,710	7,230	7,260	7,850	9,260	0.8%
Oceania	8,890	10,110	11,470	11,590	11,620	12,450	12,530	1.2%
Rest of the World	7,720	8,470	9,330	9,980	11,340	12,620	13,800	2.0%
World	5,710	6,110	6,670	7,130	7,970	8,870	9,840	1.8%

Source: World Bank (2013) State of the Tropics project.

*Gross domestic product measured at purchasing prices parity in constant 2005 international dollars.

Box 7.1.2 Spreading the wealth

The distribution of income is an indicator of how the benefits of economic growth are shared across a nation's population, with a relatively 'equal' distribution suggesting that benefits are broadly shared. A criticism of economic growth as an indicator of changes in individual wellbeing is that in some countries national income growth has not been equally distributed across the population, with a large proportion of benefits accruing to the rich. In these instances economic growth's potential impact in reducing poverty and improving living standards are constrained. That is, inequality can dampen the poverty reduction impact of economic growth.

A number of measures are available to assess income distribution, including the share of national income accruing to the poorest 20% of the population, the proportion of the population living in poverty and the GINI index. Each measure has its strengths and weaknesses, and data for each is collected infrequently. The proportion of the population living in poverty is not an indicator of the distribution of income per se, but it does provide insight into how the benefits of economic growth filter down to the most vulnerable sections of society.

A benefit of poverty as an indicator is that conceptually it is easy to interpret, as fewer people living in poverty can be viewed as a socially positive outcome. Of the measures of income distribution, it also has the greatest number of data points. In developing nations of the Tropics it is estimated that 51% of the population was living on less than \$1.25 per day in 1981, falling to 29% in 2008. The largest improvement was in South East Asia where the proportion of the population living in poverty fell from 70% to 20%, followed by South Asia (from 59% to 37%). Given population growth and changes in the distribution of income, despite a decrease in the proportion of the population living in poverty in South Asia the actual number of people living in poverty is estimated to have fallen only slightly, while in South East Asia there has been a significant reduction in the number of people living in poverty.

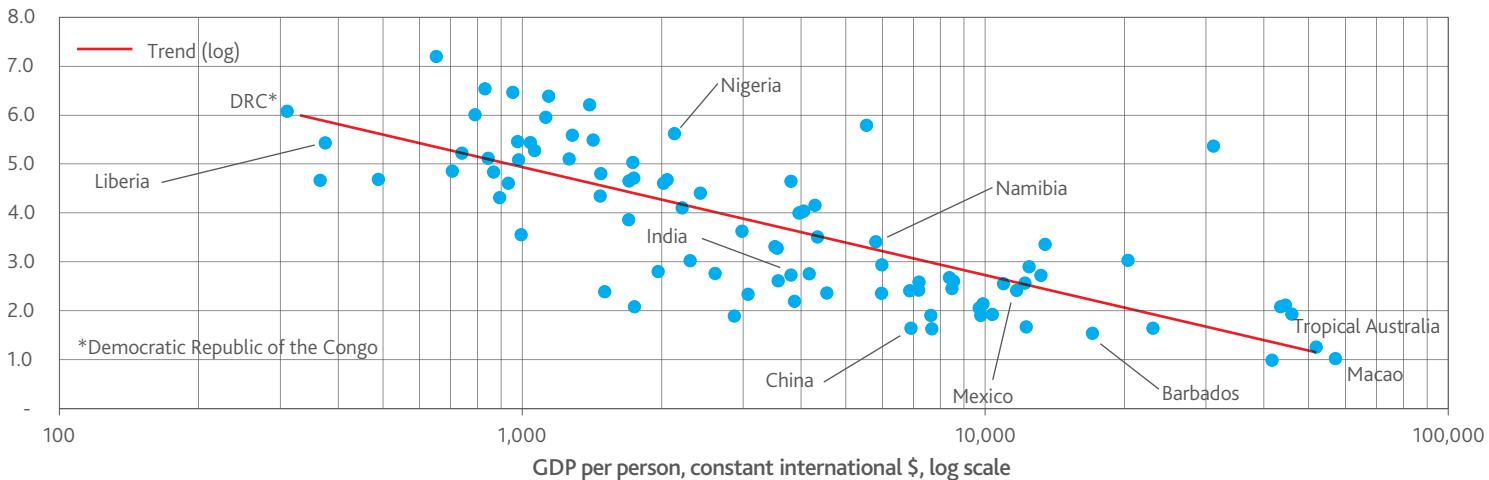
Poverty estimates calculated with PovcalNet: the on-line tool for poverty measurement developed by the Development Research Group of the World Bank. Available at: <http://iresearch.worldbank.org/PovcalNet/index.htm>.



Vietnam. Image: United Nations Photo.

Figure 7.1.3 The Tropics – proportion of global economic activity*

Fertility Rate



Source: World Bank (2013), State of the Tropics project

*Measured at purchasing price parity in constant 2005 international dollars.

Table 7.1.3 Fertility rates

								Change (#)	Change (#)	Change (#)
	1950-1955	1955-1960	1965-1970	1975-1980	1985-1990	1995-2000	2005-2010	1950-1980	1980-2010	1950-2010
Tropics	6.15	6.17	6.06	5.24	4.48	3.75	3.35	-0.91	-1.89	-2.80
Central & Southern Africa	6.56	6.59	6.75	6.93	6.72	6.14	5.58	0.38	-1.35	-0.98
Northern Africa & Middle East	6.76	6.83	7.03	7.25	7.09	6.39	5.57	0.50	-1.69	-1.19
South Asia	5.93	5.94	5.74	4.96	4.11	3.28	2.63	-0.96	-2.34	-3.30
South East Asia	5.94	5.95	5.92	4.46	3.44	2.44	2.21	-1.48	-2.25	-3.73
Caribbean	5.31	5.24	5.08	3.70	3.27	2.77	2.41	-1.61	-1.29	-2.90
Central America	6.74	6.81	6.66	5.39	3.98	3.15	2.62	-1.35	-2.77	-4.12
South America	6.38	6.38	5.74	4.51	3.37	2.70	2.22	-1.87	-2.30	-4.16
Oceania	5.36	5.48	5.04	4.52	4.01	3.79	3.44	-0.84	-1.07	-1.91
Rest of the World	4.53	4.42	4.39	3.23	2.99	2.21	2.06	-1.30	-1.18	-2.47
World	4.97	4.91	4.85	3.85	3.45	2.73	2.53	-1.12	-1.32	-2.44

Source: UN (2013), State of the Tropics project

Box 7.1.3 Productivity and economic growth

Economic growth is a function of factor accumulation (an increase in inputs to the economic process, such as a larger labour pool or more land under agriculture) and productivity improvements (more output from a given level of inputs). With accumulation, adding more inputs does not increase the income earned per unit of input, while productivity improvements generate more output and income per unit of input, including for the existing commitment of resources.

In most nations productivity is the primary determinant of growth in GDP per capita, and the link between living standards and productivity will become even more critical as societies age and the proportion of the population engaged in the labour force falls. Looking forward, productivity growth will be enhanced by the application of new technologies and organisational innovation, as well as government investment in infrastructure and policies that promote education and skills development.

development as it is a necessary condition for social development. What are some of the conditions for economic development? Traditional economics points to increases in the factors of production such as labour (through increases in the working age population and/or participation rates), capital (capital deepening) and productive land. More efficient use of the factors of production – that is, improved productivity – is also crucial (see Figure 7.1.1 and Box 7.1.3), and the source of productivity improvements will vary from country to country. Critically underpinning how factors of production are utilised are government development policies, and the regulatory environment that supports industry development and entrepreneurship.



Construction in Philippines. Image: Nonie Reyes, World Bank.

Looking forward

The need to balance economic and environmental sustainability is an issue for all nations. In many nations, and especially developing nations, achieving this balance will be a challenge as governments and populations strive to dramatically improve living standards and social conditions, while also maintaining the environment and political stability. There have been some cases of decoupling environmental pressures from economic growth, but often this has been associated with globalisation, and richer nations relocating environmental and social impacts to poorer nations. For all nations, pursuing short term economic development strategies that ignore environmental impacts is generally shown to be ill advised in the longer term.

Climate change is also an important consideration in future economic development, and is expected to have greater effects on the poor and other vulnerable people and nations (Metz et al 2007). Mitigation measures will be important policy considerations for larger tropical nations but adaptation to the impacts of climate change should be a serious policy consideration of all tropical nations.

Public sector debt service burden

Public sector debt and deficits concern governments throughout the world. All nations have some form of public debt, but it is the ability to pay that debt that indicates whether it is sustainable or not. Government debt is money owed by a national government. It can be categorised as internal debt (owed to local lenders) and external debt (owed to foreign lenders).

Governments usually borrow by issuing securities, government bonds and bills. Low levels of debt are typically considered preferable to high levels (despite many high income nations also having high levels of debt), but what is really critical, is how funds are used and the capacity of the government to repay that debt. Debt 'crises' are caused not so much by the level of the debt but rather in the capacity to serve it (Sjaastad 1983).

Nations which struggle to meet their debt obligations are often faced with high unemployment and devalued currencies with flow-on effects to standards of living and development.

Government revenue that could be allocated to public good programs is often diverted to service debt. One of the targets of the United Nations' Millennium Development Goals (MDGs) is to deal comprehensively with developing countries' debt, showing the importance of this indicator for the sustainable development of many nations (United Nations 2012).

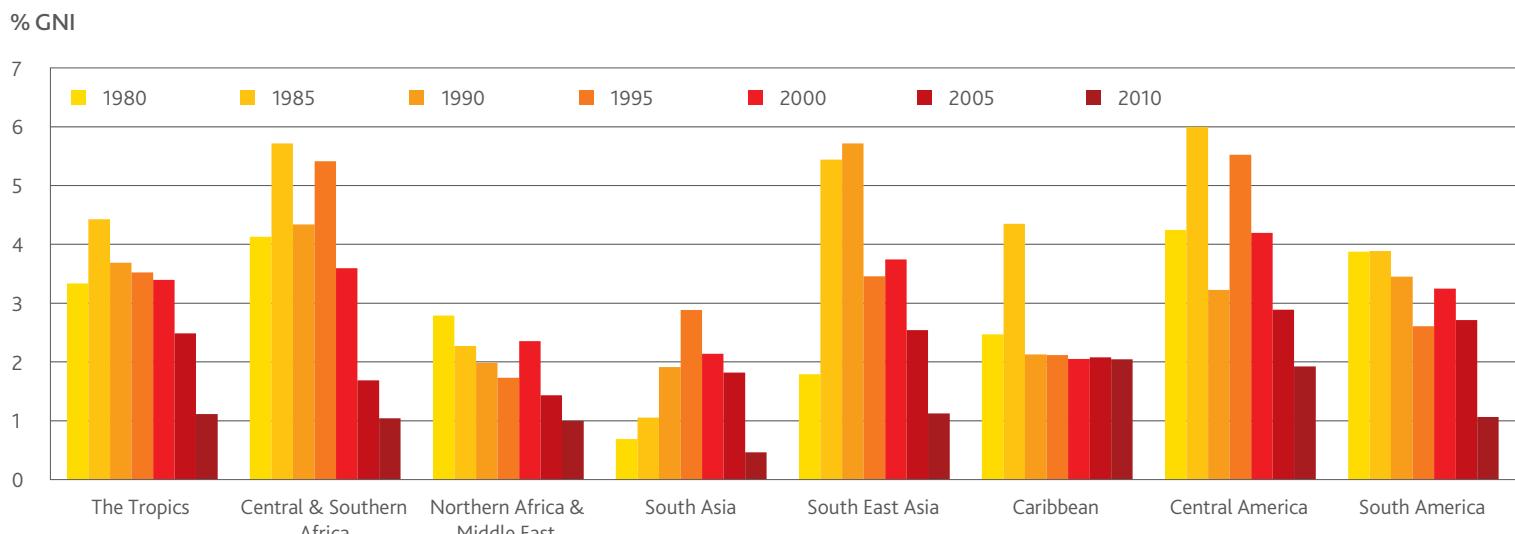
Many nations, especially poor nations, must borrow money to invest in capital and development projects, however, the combination of a narrow export base, poor policies and weak institutions place these nations at high risk of debt distress. Tension exists between taking on debt to finance national development strategies that encourage growth, and maintaining debt sustainability. Export shocks such as changes in commodity prices, particularly for natural resources, can have severe repercussions for nations with high debt burdens.

Total debt service is the sum of principal repayments and interest paid on long and short term debt and repayments to the International Monetary Fund (IMF) and other creditors. Data are public and publicly guaranteed debt service as a percentage of Gross National Income (GNI).

Trends

Although variable, public sector debt service burden has declined across most regions of the Tropics over the past three decades (see Figure 7.1.4). Remaining at more than 3% of GNI in the 1980s and 1990s, due to debt crises in Latin America and Africa, it has decreased rapidly since 2000 to be around 1% of GNI in 2010. Comparisons cannot be made with the Rest of the World as comparable data are not available for many nations.

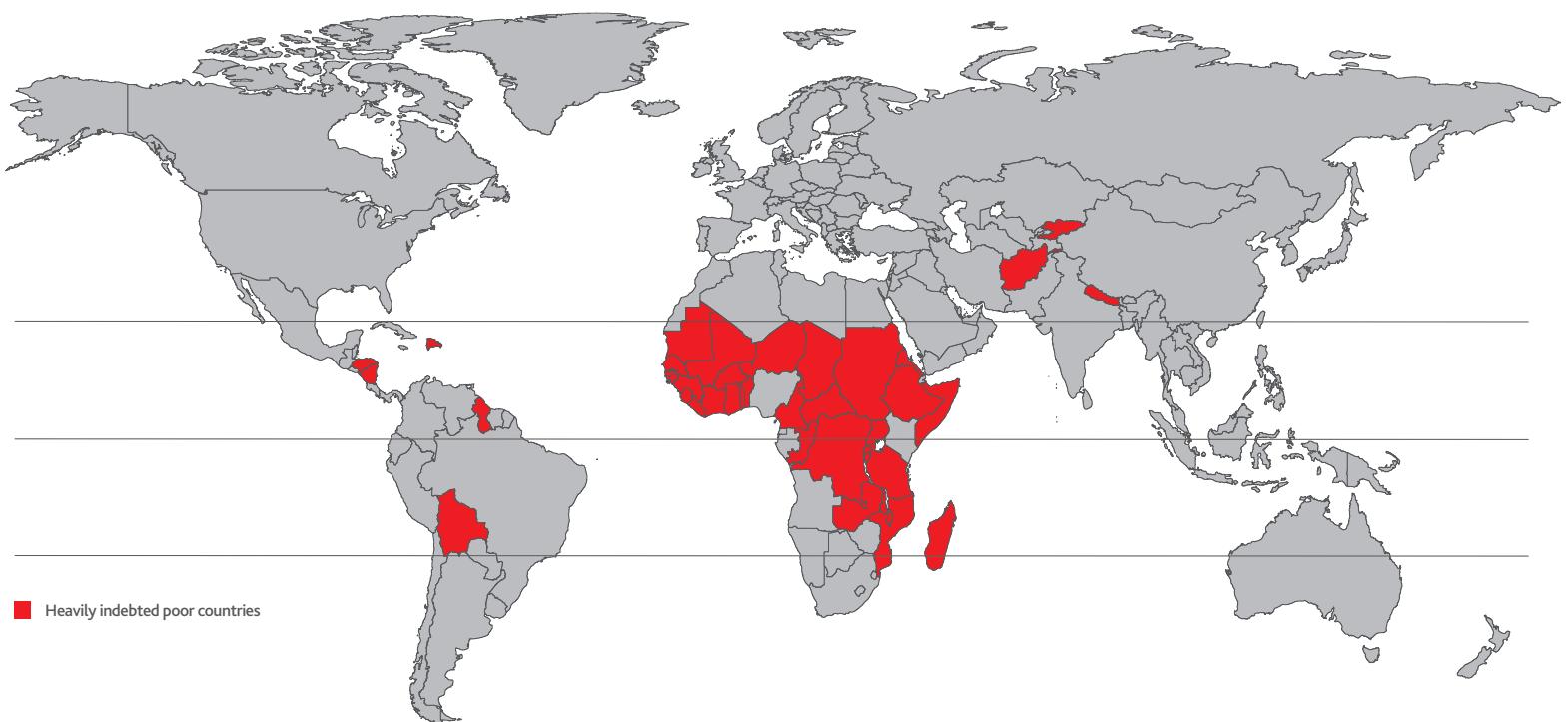
Figure 7.1.4 Debt service burden, the Tropics (% GNI)



Source: World Bank (2013), State of the Tropics project.

Note: There are no data available for Oceania. The Caribbean only includes data for the Dominican Republic. Other large economies omitted from analysis due to data availability are Tanzania, Nigeria, Saudi Arabia, Hong Kong, and Singapore.

Figure 7.1.5 Heavily indebted poor countries that have qualified for debt relief*.



Source: Source: IMF (2013).
*As of September 2013

Central America, driven by Mexico had a debt service burden of almost 2% in 2010, the second highest in the Tropics. However this is a vast improvement since the 1980s and 1990s which saw debt service rise to 6% of GNI. Rapid improvement has followed the Mexican debt crisis in 1994 when the peso was devalued and a new debt agreement had to be negotiated with the United States and International Monetary Fund.

Central & Southern Africa, Northern Africa & Middle East, South East Asia and South America have shown similar patterns of high debt service during the 1980s and 1990s and rapid improvement since the turn of the century.

The decline in debt burden from 2000 to 2010 across the Tropics can be attributed to a number of factors including strong economic growth, a rise in export earnings, high international prices for primary commodities and a marked shift in external financing from debt to equity in a number of developing nations (World Bank 2013). Debt restructuring and outright debt relief from official and private creditors, due to programmes such as the Heavily Indebted Poor Nations (HIPC) Initiative and the Multilateral Debt Relief Initiative (MDRI) would have also had some impact (even though these initiatives are focused on very low income nations with relatively small contributions to regional GNI) (IMF 2013).

The shift from external debt to equity has been important particularly for middle income nations not eligible for debt relief. It represents investments being made in tropical nations where previously, those nations had to borrow to finance certain capital projects. It also means the risks associated with new capital and developments are shared more widely, increasing the resilience of the investment.

Although not detectable in aggregated time series data, the global economic and financial crisis (2008 and 2009) has had an impact on debt burden worldwide, but recent data for developing nations has shown an improvement to 2010.

Box 7.1.4 Debt relief for disasters – the 2004 Indian Ocean tsunami

In 2004, a massive undersea earthquake triggered a series of devastating tsunamis along most coastlines of the Indian Ocean, killing more than 230 000 people, and displacing nearly 2 million people. It is considered one of the deadliest natural disasters in recorded history. Indonesia suffered the most loss of life and property followed by Sri Lanka, India and Thailand.

In response to the disaster, the four most affected nations were offered a debt moratorium by some of the wealthiest economies in the world (The Paris Club – see Box 7.1.5), in addition to foreign grants and concessionary loans from multi-lateral organisations (Okoth 2012). India, Indonesia and Thailand refused to accept the debt moratorium. In this case, accepting debt relief had the potential to be counter-productive. The nations proposing

the debt relief did not hold the debt, so there was potential damage to the debtor nations' credit ratings and future access to funding from private capital markets. The Paris Club would have had to convince commercial creditors to write off the debt. Sri Lanka accepted US\$500 million worth of debt moratorium for one year (2005) (Saravananthan & Sanjeewanie 2008).

The nations which refused debt relief did accept concessionary (interest free or low cost) loans for the reconstruction of damaged infrastructure such as roads, bridges, telecommunications, transport systems, schools and hospitals. This proved to be an effective use of funds as it allowed the affected nations to develop public capital (an investment in the future) and still service their debts (Okoth 2012).



Rebuilding after the tsunami in Thailand. Image: Michael Sarver.

Debt relief programs

Debt service is a major issue affecting economic and human development prospects in many of the world's poorest nations. Since the late 20th century, there has been a strong focus by the international community on reducing the debt burdens of the world's poorest nations. A number of programs arising from G8 nations, the World Bank, Asian Development Bank, African Development Bank and International Monetary Fund are working to relieve debt in low income nations (IMF 2008).

The Heavily Indebted Poor Countries (HIPC) initiative was launched in 1996 by the World Bank and International Monetary Fund and aims to ensure that no poor nation faces a debt burden that it cannot manage. All but three of the 39 HIPCs are found in the Tropics, and most of those are in tropical Africa (see Figure 7.1.5). In order for nations to qualify for debt relief under this Initiative, they must meet certain criteria, commit to poverty reduction through policy changes, and demonstrate a good track record under programs supported by loans from the IMF and World Bank. During the initial stage, the International Monetary Fund and the World Bank provide interim debt relief and when a nation meets its commitments, full debt relief is available.

To help accelerate progress towards the United Nations Millennium Development Goal (MDGs) to deal comprehensively with developing country debt, the Multilateral Debt Relief Initiative (MDRI) was added to HIPC Initiative in 2005. This Initiative allows for 100% relief on eligible debts held by the IMF, World Bank and the African Development Fund (IMF 2013).

Although these programmes have reduced public debt in many nations, debt relief as an instrument to relieve poverty and promote development has received some criticism. Between 1989 and 1997, total debt forgiveness to poor nations totaled US\$33 billion. During the same period, new borrowing by the same nations was estimated to US\$41 billion (Easterley 2000). Without the necessary strong institutions and governance,

debt relief may only succeed in transferring limited resources to corrupt governments with proven track records of misusing aid, potentially aggravating poverty among the world's most vulnerable populations (Easterley 2001, Chauvin & Kray 2010).

Despite a number of private creditors taking part in debt restructuring (e.g. The London Club, see Box 7.1.5), not all are willing to deliver debt relief under these initiatives. Some commercial creditors have been unwilling to extend relief under the HIPC initiative, leading to arrears accumulation, which can contribute to a rise in debt stock (Kutessa & Nabuumba 2004). Some creditors have even taken their debtors to court, suing for full payment of debt plus compensation.

There is evidence, however, where debt relief has had positive results in tropical nations. In Tanzania, savings from debt relief have been directed towards education; increasing school enrollments, building new classrooms, and recruiting more teachers. Debt relief in Mozambique led to 50 new HIV/AIDS testing and counseling offices being opened by 2007 (IMF 2013). The bulk of debt relief in Uganda has helped fund universal primary education, doubling school enrollment between 1997 and 1999 (Kutessa & Nabuumba 2004). An investigation across all HIPCs demonstrated that infant mortality rates decrease once nations receive debt relief through the initiative (Schmid 2009).

The challenge for multilateral organisations such as the World Bank and IMF is to ensure that debt relief and debt forgiveness programs really do lead to government reforms that enhance the economic and human development prospects of all people.

Debt-for-nature swaps

Nations under high debt stress often engage in economic activity with negative environmental outcomes such as deforestation (Torras 2003). Considered a win-win action for both the economy and the environment, debt-for-

nature swaps are a financial instrument which exchange debt reduction or cancellation for prescribed conservation activities (Goekel & Gray 2011). Introduced in 1987 with an agreement between Bolivia and Conservation International, over the next ten years debt-for-nature swaps accounted for US\$134 million worth of commercial developing nation debt. The majority of these projects were focused on tropical forests; improving protected area governance and promoting alternatives to deforestation (Raghabendra & Schartan 2001).

The significance of debt-for-nature swaps has declined since the mid-1990s due to the development of much larger debt relief programs (such as the HIPC Initiative and MDRI mentioned above). Additionally, concerns around the relatively small contribution to overall debt stock and whether they resulted in true economic and conservation outcomes, led to widespread criticism of these debt swaps (Knicker 2012). However, the vital role of tropical forests in limiting the likelihood of dangerous climate change has facilitated a renewed interest in debt-for-nature swaps in recent years, particularly for tropical nations such as Indonesia, Vietnam and Brazil which fall outside of the HIPC/MDRI framework (Cassimon et al. 2012). Although not a magic bullet, debt swaps could be considered one of a number of approaches for reducing deforestation and encouraging good environmental outcomes in the Tropics while alleviating debt service.

Looking Forward

Tropical nations will probably never be free of public debt. Indeed, in many cases, borrowing money is essential for ongoing development in the region. A challenge for all nations, particularly in the face of current economic instability, will be to manage this debt so that repayment does not trade off health, education and environmental development. Given tropical nations are amongst the poorest in the world, and carry high amounts of debt relative to income, this will be particularly important. Debt relief programs may alleviate debt problems temporarily but also have the potential

Box 7.1.5 Where does the money come from?

The international lending and borrowing environment is complex. Most debt operates through the sale of treasury bonds to the local or international private sector. However, in many tropical nations, large private enterprises capable of purchasing government bonds are rare. Those nations must borrow the bulk of needed funds from international lenders, both public and private.

The World Bank

The World Bank Group comprises two institutions: the International Bank for Reconstruction and Development (IBRD); and the International Development Association (IDA). The IBRD aims to reduce poverty in middle-income and credit worthy poorer nations, while the IDA focuses exclusively on the world's poorest nations. In the world of international finance, the World Bank provides low-interest loans, interest free credits, and grants to developing nations. They also facilitate financing through trust fund partnerships. The World Bank finances its activities through selling bonds in the world market; capital funds from shareholders (most nations in the world are shareholders) and sourcing grants from its 40 donor nations.

The International Monetary Fund

The International Monetary Fund (IMF) is an international organisation funded largely through its 188 member nations by quota payments and separate contribution-based trust funds. It provides advice on financial risks and fiscal policy and has the capability to provide loans to nations

having trouble meeting their international payments and cannot otherwise find finance on affordable terms. This financial assistance is designed to help nations restore macroeconomic stability by rebuilding international reserves, stabilising their currencies, and paying for imports.

The Paris Club

The Paris Club is an informal group of official creditor nations (large economies) which facilitates coordinated and sustainable solutions to the payment difficulties experienced by debtor nations. Initially it was founded to make decisions around postponing payments to ease the debt burden, but rescheduling debt payments only served to pass the debt burden on to future generations. During the 1980s, amidst the Latin-American and African debt crises, the Paris Club moved more of their activities and funds towards debt relief including debt cancellation for low income nations. In order to receive debt relief, a debtor nation must satisfy a number of criteria approved by the IMF and the Paris Club.

The London Club

The London Club represents commercial creditors, generally banks, exposed to developing nation debt. On a case-by-case basis a sub-committee of bankers works with nations to restructure commercial debt. The London Club is most active in Latin-America and South East Asia. It also provides a variety of refinancing bonds and market-based instruments such as debt conversions and buy-backs.

to encourage governments to keep borrowing with the expectation that their debt will be forgiven. Debt relief should be considered as one source of financial resources, to be used in addition to several others.

Incentives and debt swaps, rather than debt forgiveness, for development and environmental programs might be a way forward, but ultimately, tropical nations will need strong policies and governance so borrowed money is invested responsibly, allowing for debt service as well as development.



World Bank headquarters, Washington DC. Deborah W Campos, World Bank.

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PNG YUS 12oz

For the first time ever, Caffe Vita and Woodland Park Zoo's Tree Kangaroo Conservation Program bring you coffee directly from the Yopno Uruwa Som (YUS) Conservation Area in Papua New Guinea.

This limited harvest was grown under native shade at elevations ranging from 1200-1500 meters by farmers who have committed to conserving 180,000 acres for the preservation of the endangered Matschie's tree kangaroo.

Comprised of typica and bourbon, this coffee is mellow and honey-like, with flavors of toasted hazelnut, orange zest, guava, and sugarcane.



WOODLAND
PARK ZOO



CAFFEVITA.COM

FARM
DIRECT

A vertical strip on the left side of the page shows a dense plantation of coffee trees, likely YUS coffee, growing in a hilly or mountainous terrain. The leaves are dark green and textured.

Chapter 7.2

Economy | International trade and investment

Summary of trade and investment indicators

Indicator	Tropics	Central & Southern Africa	Northern Africa & Middle East	South Asia	South East Asia	Caribbean	Central America	South America	Oceania	Rest of the World	World
Exports of Goods and Services % of GDP (1980-2010)	26-47	29-36	56-48	7-23	57-90	47-46	15-32	15-16	15-19	18-25	19-25
Imports of Goods and Services % of GDP (1980-2010)	26-46	29-38	28-36	12-27	55-83	54-51	17-35	14.6 – 15.1	16-21	19-25	20-28
Foreign Direct Investment In-flows % of GDP (1980-2010)	0.7-3.5	0.4-4.0	-1.5-6.1	0.1-1.5	1.6-5.7	1.0-2.4	1.1-2.4	0.6-2.4	1.0-2.4	N/A	N/A

Nations and their economies do not and cannot exist in isolation. Human communities have been trading with one another for millennia, and trade has been a vital contributor to the development of human societies and culture. Global markets ensure that no nation is isolated or remote from changes and developments in other nations. Ideally trade consists of one nation selling what it is best able to produce and buying what others produce better. It is generally considered to be better than aid as an engine of development. Similarly investments from one nation into another promote growth and share risk. However, unless open markets are combined with secure property rights and stable government, increased economic connectivity can cause instability.

Headline Indicator

Exports of goods and services provide an indication of a nation's integration with the global economy. Exports are an indicator of global demand for the commodities, goods and services created in an economy. Exports consist of transactions in goods and services from residents to non-residents.

Supplementary indicators

Imports of goods and services provide an indication of a nation's integration with the global economy and reflect a nation's demand for commodities, good and services from other nations. Imports consist of transactions in goods and services from non-residents to residents.

Foreign direct investment (FDI) can contribute to developing a nation's productive capacity and is a measure of the extent of economic globalisation. FDI is a measure of foreign ownership of productive assets such as factories, mines and land. It can be for the creation of new capital or can involve the transfer of ownership of existing capital.

Links to other dimensions

Gross capital formation, economic growth, research and development expenditure.

Is it getting better?

Exports:

Exports of goods and services as a percentage of GDP have grown rapidly in the Tropics over the 30 years to 2010, increasing from 25% to 47%. Export earnings however, were only 21% of global totals in 2010. South East Asia has the highest percentage of exports to GDP in the Tropics (90%) and South Asia showed the strongest growth. Export growth in other regions were mixed although generally positive except for Northern Africa and the Middle East and the Caribbean where small declines in exports relative to GDP was estimated.

Imports:

Imports of goods and services to tropical nations have increased rapidly in the 30 years to 2010 from 26% to 45% of GDP. The volume of imports to

the Tropics grew by 210% during this period. Similar to exports, South East Asia imported the most relative to GDP (83%). South Asia reported strong growth in imports rising from 12%-27%. All other regions grew by smaller increments except for the Caribbean which showed a small decline.

Foreign direct investment:

Foreign investment increased in all regions of the Tropics in the 30 years to 2010. FDI to tropical nations increased more than tenfold between 1980 and 2010, from US\$11 billion to US\$157 billion. Foreign Investment is an important driver of economic growth in developing regions.



Timber market, Cameroon Image: Olivier Girard CIFOR.

Trade of goods and services

Trade can be considered a measure of how integrated a nation or region is with the global economy. Since World War II the value and volume of trade has continued to grow steadily. As a share of global output, in 2011 it was three times the level it was in the early 1950 (IMF 2011). This growth in global trade has been achieved by greater integration of global economies; a move to greater technological and skills specialisation; the rise of developing world trade driven by lower production costs; more efficient transport networks; and the rise in overall wealth world-wide.

Exporting is the sale of goods and services to another nation, and generates foreign currency revenue and economic development opportunities in the selling nation. Exports are generally driven by demand and market prices. Importing is the purchase of goods and services from other nations and is an essential element in economies. Very few nations can efficiently produce all the goods and

services that societies require for investment and consumption purposes.

Goods that are traded include primary products like oil, minerals, timber and food stuffs, and manufactured goods. Services include traded skills, information, knowledge and tourism.

Imports have a fundamental economic relationship with exports, and together they determine a nation's balance of trade. When the value of imports is less than exports there is a trade surplus. When the value of imports is greater than exports a trade deficit will result. Persistent trade deficits can drain financial resources and affect national income and savings as well as investor confidence (The Economist 2011).

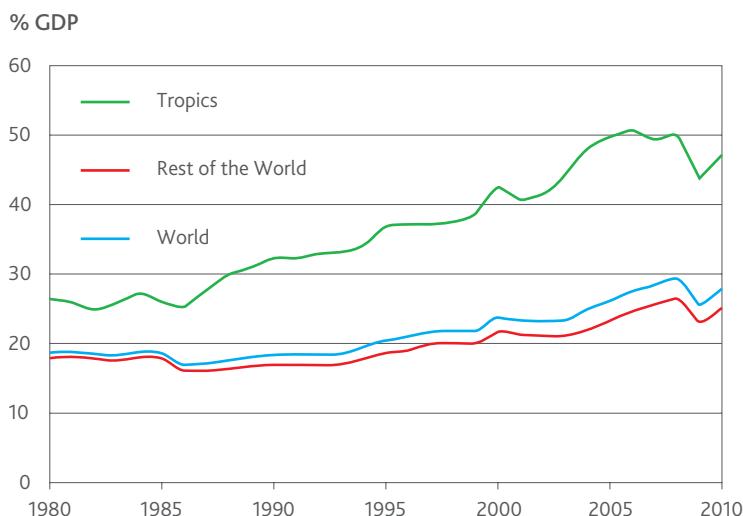
Exports can play an important role in economic activity, and in some nations export growth is instrumental in boosting GDP. In developing nations exports tend to be a higher proportion

of GDP than in wealthier nations. A factor contributing to this is relatively low production costs for many primary and manufactured goods and for some services. Although commodities are traded throughout the world, nations in Europe and North America are the greatest importers. Increasingly however, emerging economies such as India, China and Brazil among others have growing import demands (Michalopolous & Ng 2013). This includes demand for inputs and skills to support economic and social development. Increased manufacturing activity in the Tropics has also required greater demand for technology commodities and intermediary inputs to the production process (such as minerals and energy), and growing wealth is increasing demand for imported consumer goods.

Regions that rely on food and agricultural imports for domestic consumption, such as sub-Saharan Africa and the Caribbean, are especially vulnerable to the impacts of exchange rate fluctuations and global supply and demand dynamics that affect prices for the basic commodities needed to sustain life (Valdes & Foster 2012). This can also have balance of trade impacts if there are no readily available and affordable substitutes when prices rise.

In recent decades trade growth has been a powerful mechanism for economic growth, and many nations are now committed to binding international trade agreements. This has supported foreign investment into low-cost developing nations – including those in the Tropics – putting downward pressure on prices for many internationally traded goods and services consumed in developing nations – further supporting increased demand. In developing nations, increased demand for the goods and services they produce supports financial inflows and investment for economic and social infrastructure. This has contributed to employment and income growth, skills development and opportunities to diversify the export base.

Figure 7.2.1 Goods and services exports as a percentage of GDP



Source: World Bank (2013), State of the Tropics project.

Note: Regional estimates include intra-regional trade, not just trade out of the region.

Export trends

Exports as a percentage of GDP increased rapidly in the Tropics in the 30 years to 2010 compared with the Rest of the World (see Table 7.2.1). In the Tropics exports increased from 26% to 47% of GDP between 1980 and 2010, while in the Rest of the World exports increased from 18% to 25% of GDP. Despite this growth, the value of exports from the Tropics was only 21% of global totals in 2010, up from 13% in 1980. Reflecting growing trade liberalisation, global exports as a percentage of GDP increased steadily between 1986 and the start of the global financial crisis (GFC) in 2008 (see Figure 7.2.1). The GFC affected global confidence and demand, with the direct impacts being greatest in large economies in North America and Europe. This had flow-on effects to economies that rely on nations in these

regions for export revenue, with weaker demand resulting in falling export revenue. Export growth in the regions of the Tropics has been mixed since 1980. With the exception of Northern Africa & Middle East and the Caribbean, all regions recorded an increase in exports as a percentage of GDP between 1980 and 2010 (see Table 7.2.1). Nonetheless, the growth trajectories have not always been steady, and there have been periods of volatility.

In the Tropics, South East Asia has the highest rate of exports as a percentage of GDP, estimated at 90% in 2010 (though down from 98% in 2005). Even in 1980 though, exports were a major contributor to economic growth in South East Asia, and represented 57% of GDP. Exports from Hong Kong have increased most notably, up from 90% of GDP in 1980 to 219% in 2010, and this has

been a large factor in export growth in the region (see Box 7.2.1). Exports from Singapore are also consistently high at between 150% and 230% of GDP. Growth in exports as a percentage of GDP in the region is driven by strong growth in China, Malaysia and Thailand.

South Asia recorded a strong increase in exports to GDP in the thirty years to 2010, from a low base of 7% of GDP in 1980. Strong growth in exports can be credited to the introduction of trade liberalisation policies in India and Bangladesh from the early 1990s. Exports were 23% of GDP in 2010 – still below the rate for the Tropics, but close to the rate for the Rest of the World.

Compared with other regions of the Tropics, South America and Oceania report relatively low exports as a percentage of GDP, and

Table 7.2.1 Goods and services exports as a percentage of GDP

	1980	1985	1990	1995	2000	2005	2010	PPT* Change 1980 - 2010
Tropics	26.4	26.0	32.4	37.0	42.6	49.8	47.1	20.7
Central & Southern Africa	29.3	27.6	32.0	36.9	40.5	40.5	35.7	6.4
Northern Africa & Middle East	56.2	27.5	35.3	33.3	38.2	51.7	48.5	-7.7
South Asia	7.4	6.3	8.0	11.9	14.1	19.7	22.6	15.2
South East Asia	57.4	55.7	68.8	73.6	86.4	97.8	90.2	32.8
Caribbean	46.6	45.9	50.9	50.3	51.6	55.0	45.5	-1.1
Central America	14.5	17.0	20.7	31.7	32.2	29.6	32.3	17.8
South America	14.5	15.3	15.4	12.0	14.5	20.0	15.8	1.3
Oceania	14.7	12.3	13.6	17.0	18.0	17.0	18.7	4.0
Rest of the World	17.9	17.8	17.0	18.6	21.7	23.3	25.1	7.2
World	18.7	18.6	18.4	20.5	23.8	26.1	27.9	9.2

Source: World Bank 2013, State of the Tropics project.

* Percentage point change. ** Estimate based on nations for which data are reported.

Note: Regional estimates include intra-regional trade, not just trade out of the region

only modest growth in the rate since 1980. Exports as a percentage of GDP have increased significantly in Central America, with rapid growth in the mid-1990s due to the North American Free Trade Agreement between the United States, Canada and Mexico coming into force in 1994 (see Box 7.2.2). Nonetheless, after the early promise of growth, the rate has remained around 30% of GDP for the past 15 years.

Exports as a percentage of GDP declined in Northern Africa & Middle East between 1980 and 2010, and varied between 28% and 56% over the period. This is largely due to fluctuating prices and demand for oil exports from Saudi Arabia – the dominant economy in the region. The Caribbean also recorded a modest decline in the rate of exports as a percentage of GDP, largely affected by Cuban exports falling from 33% of GDP in 1980 to 19% of GDP in 2010.

Import trends

As a percentage of GDP, imports of goods and services to nations in the Tropics increased at a faster rate than in the Rest of the World in the years to 2010. In the Tropics the value of imports increased from 26% of GDP in 1980 to 45% in 2010 (see Figure 7.2.2). The increase in the Rest of the World was more modest, up from 19% in 1980 to 25% in 2010.

As global trade is increasingly integrated, the flow of imports and exports tend to track closely. Goods that are imported can be either consumed in the importing nation, or transformed into new goods or services that can be either consumed in the domestic economy or exported. The global financial crisis in 2008 not only led to a worldwide decline in exports, but also imports, as reduced demand from developed nations had a flow-through to demand for imports to the production process from exporting nations.

With the exception of the Caribbean, all regions of the Tropics reported an increase in imports as a percentage of GDP between 1980 and 2010 (See Table 7.2.2). In the Tropics, imports as a percentage of GDP are highest in South East Asia, at 83% in 2010, with Hong Kong, Singapore, Thailand, Malaysia and China being major importers. Other factors influencing strong import growth in the region include export growth in China and Thailand.

Imports in Central America increased from 17% of GDP to 35% in the 30 years to 2010. Mexico's involvement in NAFTA from 1994 drove most of this increase (see Box 7.2.2). South America reports only minor growth in imports as a percentage of GDP in the 30 years to 2010.

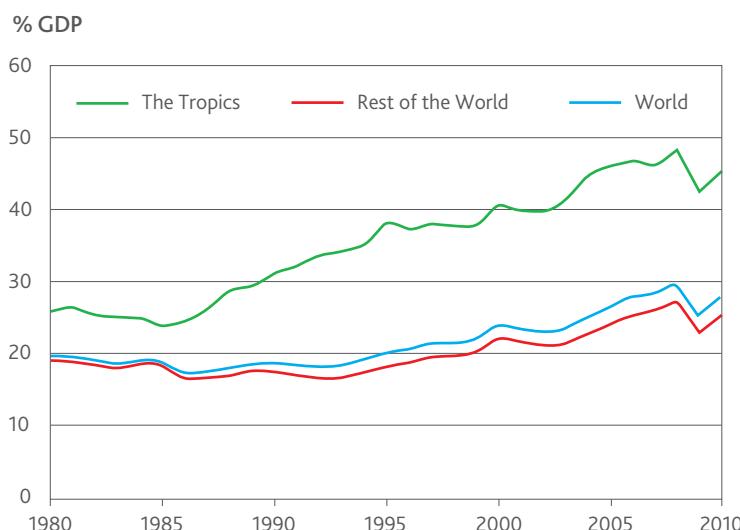
South Asia reported the lowest imports as a percentage of GDP in 1980 at 12.2%, but in the 30 years to 2010 it increased to 27%, higher than South America and Oceania. Strong import and trade growth in South Asia is attributable to the introduction of more liberal trade policies in India and Bangladesh from the early 1990s. However, even at 27% in 2010, imports as a percentage of GDP are well below the rate for the Tropics (though close to the rate for the Rest of the World).

The Caribbean was the only region in the Tropics to record a decline in imports as a percentage of GDP. Nonetheless, the fall was marginal, as reduced imports to Cuba and Barbados more than offset increased imports to Puerto Rico and the Dominican Republic.

Trade agreements

Rapid growth in international trade has been assisted by creation of the World Trade Organisation (WTO) in 1995 to facilitate and formalise international trade agreements. These trade agreements have played an important role in strong growth in international trade in recent decades, and recent advances include more liberal agreements that encourage greater cross-border trade in services and intellectual property (WTO 2011a). China joined the WTO in 2001.

Figure 7.2.2 Goods and services imports as a percentage of GDP



Source: World Bank (2013) State of the Tropics project.

Note: Regional estimates include intra-regional trade, not just imports to the region.

Box 7.2.1 The trade industry of Hong Kong

Hong Kong is the 10th largest trading economy in the world and is a signatory to three regional trade agreements – with China, New Zealand and Europe (through the Europe Free Trade Agreement, or EFTA) (WTO 2013). The trade sector employs around 500,000 people and accounts for almost 20% of Hong Kong's GDP (HKTDC 2012). Exports of goods and services have increased significantly to account for 219% of GDP in 2010, up from 90% of GDP in 1980.

Trade growth in Hong Kong has been influenced by its close proximity and historical and strategic links to China. This has made it a conduit for much of China's expanding global trade as its economy has opened up. Hong Kong is China's second largest export destination after the United States, and it receives 14% of Chinese exports. Over 50% of Hong Kong's exports are to China and 45% of Hong Kong's imports are from China. A large proportion of trade in and out of China passes through Hong Kong, and it re-exported over 60% of its Chinese imports in 2010 (HKTDC 2012).

Hong Kong has a growing trade-related service sector built on increased trade with China, and direct investment from China is increasing steadily, and now competes with investment inflows from Europe and the United States. Tourism is also a significant service export, accounting for around 4% of GDP and 6% of employment in 2010. More than 40 million people visit Hong Kong each year, and growth in visitors from mainland China is especially strong, increasing from 4.5 million in 2001 to 28 million in 2011 (Government of Hong Kong 2012).

Not surprisingly, with limited natural resources (including limited capacity to supply its own food), Hong Kong is highly dependent on international trade for economic growth. This means that Hong Kong's economic performance is closely linked to the global economy, and that it has limited capacity to manage volatility associated with the impact of external shocks that affects its major trading partners.

Trade agreements are important because they formalise trade arrangements between nations and aim to make trade less restrictive – creating opportunities for trade to expand across regions and industries. Up to 3,000 trade agreements were estimated to be in operation world-wide in 2010, with many other agreements still in negotiation phase (WTO 2011b).

The WTO is currently negotiating the Doha Development Round. Negotiations commenced in 2001 with a focus on addressing the trade needs of developing nations, including improved access to international trade and investment markets. The treatment of farm subsidies in developed nations, industrial tariffs and non-tariff barriers to trade are major obstacles hindering completion of the negotiation, and the long delay in reaching agreement is contributing to greater use of bilateral agreements between nations to encourage trade.

The Doha Round highlights the inherent difficulty in negotiating multilateral trade agreements between developing and developed nations. Trade agreements by their nature become more complex to negotiate as the number of signatory nations increases. For example, bilateral trade agreements tend to be less complex to negotiate as parties tend to have an understanding of each other, and the economic and social development opportunities and risks of entering an agreement. The North American Free Trade Agreement (NAFTA) and ASEAN Free Trade Agreement (AFTA) are examples of free trade agreements where some of the world's biggest developed economies have integrated with emerging and developing economies (see Box 7.2.2).



Hong Kong. Image: Mr Wang

Export diversity

Exports as a percentage of GDP tend to be higher in developing nations than in developed nations. Additionally, primary goods represented at least 50% of commodity exports for two-thirds of developing nations in 2010 (UNDP 2011). This reliance on primary goods means that developing nations are at a relatively greater risk of adverse impacts from external shocks such as economic downturns and fluctuating commodity prices and exchange rates.

The increased risk of a volatile economic growth outlook can affect investor confidence in traded and non-traded sectors of the economy, with impacts on longer term prospects for economic and social development. This uncertainty can also contribute to under-investment in trade

infrastructure in developing nations, including roads, railways, and ports – which is critical to developing efficient trade networks (USITC 2009).

Developed nations generally have a more diverse range of exports – including manufacturing and services – and do not rely as heavily on export revenue for economic growth (that is, a large proportion of production is actually consumed by the domestic population).

Looking forward

Imports and exports have played an important role in the ongoing economic development in the Tropics. Liberalisation policies combined with a region rich in natural resources have combined to increase exports, and rising affluence

is driving import growth. Further development of manufacturing and services industries has diversified the export market in some areas of the Tropics.

Expanding the export base of both primary products and manufacturing as well as diversifying trading partners would benefit many tropical nations. This will require regional political stability, intra-regional trading, and building on current export bases by integrating them into existing and emerging markets. Emerging large economies will have a strong demand for raw materials and consumer goods. These emerging economic regions of the Tropics are becoming some of the world's largest trading nations and will rely on trade to maintain their rate of social and economic development.

Table 7.2.2 Goods and services imports as a percentage of GDP

	1980	1985	1990	1995	2000	2005	2010	PPT* Change 1980 - 2010
Tropics	25.8	23.8	31.1	38.2	40.7	46.0	45.4	19.6
Central & Southern Africa	28.7	26.6	28.4	37.6	35.2	37.3	38.0	9.3
Northern Africa & Middle East	28.1	35.2	29.6	27.1	24.8	29.8	36.2	8.1
South Asia	12.2	9.5	10.1	13.8	15.7	22.9	27.0	14.8
South East Asia	55.3	52.4	66.9	75.1	78.7	89.2	82.6	27.3
Caribbean	53.8	51.9	59.6	62.9	64.2	61.8	51.4	-2.4
Central America	17.0	12.8	22.4	30.3	35.0	32.6	34.6	17.6
South America	14.6	10.4	11.0	13.4	14.3	14.9	15.1	0.5
Oceania	15.7	15.3	15.7	17.6	20.3	21.1	20.8	5.1
Rest of the World	19.0	18.2	17.4	18.2	22.2	24.0	25.3	6.3
World	19.7	18.7	18.7	20.2	24.0	26.4	27.8	8.1

Source: World Bank 2013, State of the Tropics project.

* Percentage point change. ** Estimate based on nations for which data are reported.

Note: Regional estimates include intra-regional trade, not just imports to the region.

Box 7.2.2 North American Free Trade Agreement

The North American Free Trade Agreement (NAFTA) between the United States, Canada and Mexico was established in 1994, creating the world's largest free trade area in terms of GDP. The agreement introduced a range of measures which encouraged trade and investment flows by reducing trading costs, increasing business and infrastructure investment and competition, and establishing frameworks for regional co-operation. NAFTA was controversial when first proposed, mostly because it was the first free trade agreement involving developed and developing nations (Villarreal & Fergusson 2013).

NAFTA has contributed to strong increases in intraregional trade flows, which increased from around \$290 billion in 1993 to more than \$1.1 trillion in 2012. Cross-border investment and travel have also increased, with United States investments to Canada and Mexico estimated at almost \$630 billion between 1994 and 2009. The United States also trades more with Mexico and Canada than with Japan, South Korea, Brazil, Russia, India, and China combined. Much of the growth in NAFTA trade has been between the United States and Mexico, where the trade balance went from a \$2 billion United States surplus in 1993 to a \$61 billion deficit in 2012 (Sergie 2014).

Rapid growth in trade in the early years of NAFTA has been tempered since 2001, affected by increased fears of terrorism following the 9/11 attack, and the impact of

China joining the WTO, and the overall economic effects from increased trade through NAFTA are considered to be relatively modest, noting there have been adjustment costs as the three nations adjusted to more open trade and investment among their economies (Villarreal & Fergusson 2013).

Looking forward though, some commentators suggest the outlook for NAFTA to encourage regional trade is improving. For example, productivity improvements in Mexico are increasing its competitiveness with China, and the protection of intellectual property rights under NAFTA improves the likelihood of complex manufacturing processes occurring in the region (as opposed to, say, China). Abundant cheap shale-gas energy in the United States and a rapidly growing working age population in Mexico will also support economic activity and trade in the region (The Economist 2014).

The negotiation of other trade agreements such as the Trans-Pacific Partnership and the Transatlantic Trade and Investment Partnership highlights that there are many opportunities to encourage regional trade, development and greater economic integration.



Vehicles ready for export from Mexico. Image: Peanutian.

Foreign direct investment

Foreign direct investment is the physical investment from a firm or corporation of one nation to another nation and is a fundamental dynamic of global economics. In recent decades there has been an exponential increase in foreign direct investment in terms of both capital and geographic reach (Hufbaur & Draper 2013). Investments assist in developing physical infrastructure and acquiring capital goods and corporate assets (Trakman 2010). Foreign direct investment also contributes to technology dissemination, skills and management practices, and can increase productivity, employment and incomes in host nations. In developing nations foreign direct investment tends to dominate capital inflows.

Ideally foreign direct investment provides financial return to investors, and economic and

social benefits to host nations. However, firms and corporations are vulnerable to political and financial risks, and host nations are at risk of dependent or restricted development. Strong governance frameworks and a robust financial sector can help to protect host nations from some of the key risks associated with large foreign direct investment flows – notably exchange rate volatility, inflation and current account imbalances.

Trends

Net foreign direct investment inflows as a percentage of GDP increased steadily in the Tropics in the 30 years to 2010, and at a significantly faster rate than the Rest of the World. Foreign direct investment in the Tropics

increased from 0.7% of GDP in 1980 to 3.5% in 2010, while in the Rest of the World it increased from 0.5% of GDP to 1.6% over the same period (see Table 7.2.3).

Despite foreign direct investment inflows representing a higher proportion of GDP in the Tropics than in the Rest of the World, in 2010 the Tropics only accounted for around 22% of global foreign direct investment inflows (US160 billion), although this up from 12% in 1980 (US10 billion).

All regions in the Tropics recorded increases in net foreign direct investment inflows as a percentage of GDP between 1980 and 2010. Higher rates of foreign direct investment have corresponded with sustained economic growth. Northern Africa & Middle East reported the highest rate of net foreign direct investment inflows in the Tropics

Table 7.2.3 Foreign direct investment – net inflows as a percentage of GDP

	1980	1985	1990	1995	2000	2005	2010	PPT* Change 1980 - 2010
Tropics	0.7	0.8	1.3	2.2	3.2	3.1	3.5	2.7
Central & Southern Africa	0.4	1.3	1.0	2.2	2.7	3.2	4.0	3.6
Northern Africa & Middle East	-1.5	0.4	1.3	-0.9	-0.1	4.6	6.1	7.6
South Asia	0.1	0.1	0.1	0.5	0.8	0.9	1.5	1.4
South East Asia	1.6	1.1	3.6	4.3	3.7	5.0	5.7	4.1
Caribbean	1.0	0.2	0.9	1.8	2.6	2.5	2.4	1.3
Central America	1.1	1.0	1.0	3.1	3.1	3.1	2.4	1.3
South America	0.6	0.8	0.4	1.1	4.3	2.5	2.4	1.7
Oceania	1.0	0.9	1.7	2.2	3.2	-0.6	2.4	1.4
Rest of the World	0.5	0.4	0.9	1.0	4.1	2.4	1.6	1.1
World	0.5	0.5	0.9	1.1	4.0	2.5	1.8	1.3

Source: World Bank (2013) State of the Tropics project.

* Percentage point change.

Note: Regional estimates include intra-regional investment

Box 7.2.3 International investment agreements and ASEAN

There is often debate about the most appropriate policy response to both attract foreign direct investment, and balance local concerns about foreign ownership and control (Nixon 2004). International investment agreements (IIAs) have emerged as an international legal framework for foreign investment. These agreements aim to ensure that nations adhere to specific standards on the treatment of foreign investments within their territory. They also define procedures for the resolutions of disputes if they were to occur. There are now more than 3,000 IIAs which include bilateral, regional and sectoral agreements (Malik 2011).

An example of a regional agreement with a strong influence on the Tropics is the ASEAN Comprehensive Investment Agreement (ACIA) which came into effect in early 2012. This agreement is designed to support a 'free, open, transparent and integrated investment regime in the Association of Southeast Asian Nations

(ASEAN) region' (ASEAN 2013 p.V). Nations involved in this agreement include Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Burma/Myanmar, Philippines, Singapore, Thailand, and Vietnam. The ACIA covers almost all forms of investment, with liberalisation provisions covering manufacturing, agriculture, fisheries, mining and the services associated with these industries. It encourages cross-border investment within the region and protects investors from policy changes in individual nations.

International investment agreements are a multifaceted network of instruments, with agreements differing in regard to their geographical coverage, scope and the content of their obligations and commitments (UNCTAD 2005). Despite this complexity, they are a powerful tool that tropical nations with abundant natural resources can use to ensure foreign direct investment results in positive outcomes for both host nations and investors.

in 2010 at 6.1% – largely related to minerals and energy investment – although in 1980 the region was a net exporter of foreign direct investment. The privatisation of oil and gas assets in Saudi Arabia since 2002 is the major factor contributing to the rapid increase in Northern Africa & Middle East's net foreign direct investment inflows in the past decade (Ramady 2010), though there have also been significant increases in several other nations.

In South East Asia net foreign direct investment inflows increased from 1.6% of GDP in 1980 to 5.7% 2010. Given rapid economic growth in this region, this represents an increase of over 2,000% in dollar terms. There was a slight setback in growth in the late 1990s associated with the Asian Financial Crisis, but net foreign direct investment inflows have since recovered strongly. Hong Kong and Singapore in particular have high net inflows of foreign direct investment as a percentage of GDP.

As a percentage of GDP the net inflow of foreign direct investment in Central & Southern Africa was 4% in 2010, up from 0.4% in 1980, with Nigeria being a major contributor to growth, largely due to foreign investment in the oil sector. In the Caribbean, Central America, South America and Oceania net inflows of foreign direct investment as a percentage of GDP were all at 2.4% in 2010, and up from around 1% in 1980. Foreign direct investment peaked in these regions in 2000 and subsequently declined. Although this may be a result of poor macro-economic performance of investor nations, it is more likely to reflect a period of consolidation following the rampant cross-border investment in the late 1990s (Christiansen & Bertrand 2004). The global financial crisis in 2008 also had a greater impact in these regions (particularly South America) than in other tropical regions (UNCTAD 2010). South Asia recorded the lowest net inflows of foreign direct investment as a percentage of GDP in the Tropics in 2010 at 1.5%. Nonetheless, South Asia has experienced a large increase since 1980 as, prior to the liberalisation of capital flows in India in 1991, equity investment in the region was largely non-existent.



Bank of Indonesia, Yogyakarta. Image: Ridzki Noviansyah.

Investment and economic growth

Foreign direct investment contributes to the development of physical infrastructure and supports economic activity. Traditionally foreign direct investment has flowed from wealthy to less wealthy nations and, to a large extent, this is still the case today, especially as there has been a global trend toward reducing trade restrictions, including capital flows.

Foreign investors are usually multinational companies and investment firms pursuing opportunities, and developing nations can offer a relatively low-cost production base – often built on a large pool of labour and supportive regulatory frameworks. Improvements in political stability can also encourage foreign investment and economic growth through encouraging development of mineral and energy resources.

In South East Asia, government policies have increasingly opened national economies to foreign investment and encouraged the development of trading partnerships over the past 30 years (see Box 7.2.3). These policies have contributed to investment in economic and social infrastructure and the development of a highly skilled workforce. The region is now one of the fastest growing economic and trading bases in the Tropics and the world, and it continues to attract high levels of foreign direct investment (PWC 2012).

Developed nations are still the major source of outward foreign direct investment, but net outflows from developing nations are increasing. Developing nations' share of global foreign direct investment outflows increased from 6% in 1980 to 27% in 2011, and there are many intra-regional foreign direct investment flows in South East Asia, South Asia, Latin America and the Caribbean (Al-Sadig 2013). China is increasingly investing in international infrastructure projects, and supporting industries based around natural resources and primary commodities, notably in Africa. Chinese foreign direct investment in these nations has strengthened trading partnerships

Box 7.2.4 Aid and foreign direct investment

The 2002 Monterrey Consensus on International Financing and Development affirms that foreign aid and foreign direct investment are complementary sources of capital and aid is essential to encourage investment in nations that are least attractive to international investors (UN 2003). These nations are typically in Central and Southern Africa or small island states in the Tropics. Although some research suggests that aid and foreign investment are unrelated, there is strong evidence, especially in sub-Saharan Africa that higher foreign direct investment goes where higher aid does (Anyanwu 2012).

Aid improves the economic and social infrastructure which can raise the relative output value of capital in poor nations and facilitate the development of more stable

financial systems thus encouraging foreign investment (Anyanwu 2012). However, other research demonstrates that the way that aid is invested can affect the influence it has on foreign investment, particularly in Africa. Aid invested directly into physical capital tends to crowd out foreign investors whereas if aid is invested into inputs complementary to physical capital, it is more likely to draw in foreign investment (Selaya & Sunesen 2012). In addition, aid has been shown to mitigate the negative effects of domestic terrorism on foreign investment (Sandler & Younas 2011). In post conflict nations, where reliable information is poor, aid can act as a signal to investors that the donors trust local officials and it is now a safe place to invest (Garriga & Phillips 2013).



International Red Cross, Central African Republic. Image: Juliette Humble, DFID.

and contributed to economic and social development (Renard 2011).

Risks for the Tropics

Despite the potential for high returns, foreign direct investment is not without risk. Performance across the Tropics has been varied, and in some regions there is little empirical evidence that foreign direct investment has had a positive influence on sustainable development outcomes (Alfaro et al. 2010). Unregulated or poorly designed foreign direct investment can actually weaken the potential benefits of investment, including the opportunity for more stable and sustainable economic development. Macro-economic effects such as inflation and currency fluctuations can have direct and indirect effects on households and purchasing power, and the effects of a reversal of capital flows on host nations can be significant (UNDP 2011).

Host nations often face greater risk than investors, particularly if they rely on foreign direct investment for infrastructure and economic development. Exchange rate fluctuations can be especially detrimental to investments in developing nations, and foreign direct investment can 'crowd out' domestic investment opportunities for local businesses (Hayakawa et al. 2011). However, it is also a risk for developing nations not to support foreign direct investment, particularly those nations that lack capital or savings to invest in business development, industrial production, and skills development (Ghose 2004).

Central and Southern Africa is a region many investors consider risky because of political instability, conflict and corruption. This can impact investor confidence, even though the region has an abundance of natural resources such as oil, minerals and timber. (Interestingly, some recent research suggests that corruption may actually have a positive effect on foreign direct investment in resource endowed nations (Ezeoha & Cattaneo 2011). However, even if this were the case, improvement in human

development is more positive when corruption is low (Anyawun 2012). Ongoing political reform and greater economic stability in many nations in the region is encouraging foreign direct investment inflows, which can account for 30% to 70% of GDP in some Central & Southern African nations (UNDP 2011). Foreign aid also tends to encourage foreign direct investment (See Box 7.2.4).

Recent policy developments demonstrate that although nations are eager to attract foreign investment many have become more selective (UNCTAD 2013). Ideally domestic investment policies should target those investments that generate jobs, deliver poverty alleviation or help tackle environmental challenges. For example, the Philippines recently released an executive order putting new mining contracts on hold until new legislation, which modifies existing revenue-sharing schemes and mechanisms, has taken effect. To ensure compliance with environmental standards, the order also requires a review of the performance of existing mining operations (UNCTAD 2013).

Looking Forward

Trade and foreign investment will continue to be important drivers of economic and social development in the Tropics and throughout the world. However, future policies should enable an international investment regime that promotes sustainable development in the region. Tropical nations will need to strike the right balance between liberalisation and regulation and enhance the interfaces between investment and development such as those between investment and poverty (UNCTAD 2010) and those that provide adequate protection for the environment.

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Solar panels, Cape Verde.
Image: Gerald R Ford School of Public Policy.



Chapter 7.3

Economy | Science and Technology

'No nation that wants to shape informed policies and take effective action can afford to be without its own independent capacity in Science and Technology'

Kofi Annan

Summary of science and technology indicators

Indicator	Tropics	Central & Southern Africa	Northern Africa & Middle East	South Asia	South East Asia	Caribbean	Central America	South America	Oceania	Rest of the World	World
Research and Development Expenditure % GDP 2000-2008	0.49 - 0.58			0.74 - 0.73	0.62 – 0.97		0.37 – 0.35	1.47 – 1.93		1.8 – 1.96	2.0 – 2.1
Tertiary Enrollments per 100,000 population 2000-2010	1190 – 2031	318 – 780	735 – 1246	875 – 1675	1563 – 2476	1419 – 6168	2361 – 3025	1967 – 3491	4210 – 6136	2085-3423	1743 – 2862
Scientific and Technical Journal Articles per 100,000 population 1990-2009	0.8 – 1.8	0.4 – 0.3	0.6 – 0.4	1 – 2.3	0.5 – 2.5	0.8 – 1	1 – 2.6	1.2 – 4	19.6 – 18	15.6 – 18.9	9.4 – 11.9

Creating and using knowledge and innovation is an essential ingredient to human development. Technological innovation is a key driver of sustained economic growth and improved welfare. Investment in science and technology is a major input to this innovation process, providing the technical basis for improvements across all aspects of society and the natural environment. The effective development and application of technology requires sufficient and appropriate infrastructure and institutions and suitably trained personnel, as well as effective linkages within and between these groups.

Headline indicator

Research and Development Investment:

Investment in research and development is a major contributor to innovation. Expenditures for research and development are current and capital expenditures on creative work undertaken to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new applications. Research and

development covers basic research, applied research and experimental development.

Supplementary indicators

Tertiary enrolments: The proportion of people enrolled in tertiary education is a representation of a nation's investment in higher education and innovation. People with appropriate skills are needed to create and apply knowledge and technology, leading to innovation and development.

Scientific and Technical Journal Articles:

Scientists, engineers and researchers share knowledge through the publication of peer reviewed journal articles. They represent a key output of the scientific process.

Links to other dimensions

Education, Economic Output.

Is it getting better?

In the Tropics, available data suggest that measures of Science and Technology are improving. Investment in research and development is increasing modestly; numbers of published science and technical journal articles and enrollments in tertiary education are growing rapidly but from a low base. There is substantial regional variation in trends.

Despite these improvements, there is less investment in research and development, fewer tertiary enrolments per population and fewer scientific and technical journal articles produced in the Tropics than the Rest of the World. Investment in technology and innovation will be important for the tropical region as a whole to be competitive in future knowledge based economies.



Image: James Cook University.

Research and development expenditure

Science and technology are critical for improving social, environmental and economic outcomes. Nations and organisations drive science and technology by investing in research and development (R&D) programs. The primary function of R&D – which covers basic and applied research – is to discover and create new knowledge, products, processes and services. This includes making or improving tools, techniques and systems to solve problems or improve existing solutions. From an economic and human development perspective, the outputs of R&D activity contribute to technological innovation, which is a critical component of sustained economic growth and improved welfare (Grupp & Mogee 2004, Tijssen & Hollanders 2006).

The innovation process is not linear, and relies on an interconnected range of market and non-market institutions to work effectively (Sachs & McArthur 2002), as well as appropriate human capital and infrastructure to generate and apply

knowledge. That is, the extent of technological innovation is affected by the strength of relevant institutions and systems, as well as the strength of linkages between them. Many economists believe the largest part of world-wide growth and development over the past ten years has been associated with greater and more efficient diffusion of technological change, and greater access to scientific and technological knowledge (Freeman & Soete 2009).

Science and technology is not always transferable across regions, ecosystems and cultures. In the Tropics, where R&D investment severely lags that of the Rest of the World, this non-transferability combined with a general lack of socially relevant, ecosystem specific, and time appropriate investment in critical areas such as health and agriculture are considered to be major factors contributing to relative underdevelopment in many parts of the Tropics (Sachs 2000). For instance, advances made

in corn production in the United States will have little direct relevance for a cassava farmer in Vanuatu. Therefore the impact of R&D expenditure is likely to be maximised where it not only facilitates the adoption of science and technology developed elsewhere, but also invests in locally relevant innovations and solutions for the Tropics.

Trends

Despite the contribution that expenditure on R&D makes to innovation, economic growth and development being well known (Freeman & Soete 2009), datasets reporting it tend to be quite poor. In the Tropics data are particularly limited for nations in Africa, the Middle East, the Caribbean and Oceania. Where data are not reported, it is likely that actual expenditure is low (Urama et al. 2010) (see Box 7.3.1).

Where sufficient data are available, it suggests that tropical nations commit a significantly smaller proportion of economic activity to R&D than in the Rest of the World (see Table 7.3.1), ranging from less than 0.04% of GDP in Honduras to 2.7% in the United States. In the decade to 2008, for the tropical nations which report data, R&D expenditure averaged 0.53% of GDP. In the Rest of the World expenditure as a percentage of GDP in 2008 ranged 0.02% in Bosnia and Herzegovina to nearly 5% in Israel, and averaged 2% of GDP in the decade to 2008.

As a proportion of GDP the Rest of the World invests almost four times as much in R&D than the Tropics but, given the difference in GDP levels, in expenditure terms the gap is even larger. In 2012 global R&D expenditure was estimated at around \$US1.4 trillion, of which US\$1.3 trillion was in the United States, China, Japan and Europe (Battelle & R&D Magazine 2012).

Although low, research and development expenditure in the Tropics has been increasing while the Rest of the World has remained constant. In the major economies of China,

Table 7.3.1 Research and development expenditure (% of GDP)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Tropics	0.49	0.50	0.51	0.51	0.52	0.55	0.55	0.57	0.58
Central & Southern Africa									
Northern Africa & Middle East									
South Asia	0.74	0.72	0.71	0.71	0.72	0.76	0.74	0.73	0.73
South East Asia	0.62	0.68	0.74	0.76	0.80	0.85	0.89	0.92	0.97
Caribbean									
Central America	0.37	0.39	0.43	0.39	0.39	0.39	0.37	0.35	0.35
South America	1.47	1.48	1.52	1.53	1.53	1.66	1.74	1.83	1.93
Oceania									
Rest of the World	2.0	2.1							
World	2.1	2.2	2.1	2.1	2.0	2.0	2.0	2.0	2.1

Source: World Bank (2013), State of the Tropics project.

Singapore, Hong Kong and, to a lesser extent, India and Brazil, R&D expenditure as a percentage of GDP increased between 1996 and 2007. In fact, over the past 15 years China's R&D as a proportion of GDP has consistently increased, and China is one of the few nations in the world where R&D spending has increased at a similar rate to GDP (Hollanders & Soete 2010). With this strong commitment to R&D activity, China is expected to overtake the United States in terms of total spending on R&D within the next ten years (Battelle & R&D Magazine 2012).

Although the reasons for relatively low levels of R&D investment in tropical nations vary, recent research suggests economic restrictions associated with credit and debt servicing constraints may be contributing to this outcome (Goni-Pachioni et al. 2012). As the majority of R&D investment in developing nations is publicly funded (Mani 2010, Cruz & Chaimovich 2010), it is influenced by government debt, aid availability and political will, as well as myriad other interests competing for government investment.

Spillover and tropical innovations

Although the benefits of R&D activity may not be seamlessly transferable to all other locations, the benefits are by no means limited to those nations that undertake the investment. Spillovers' from research spending in other nations are likely to have positive impacts for tropical regions. In fact, spillovers from nations that are big R&D spenders are thought to be substantial (Coe et al. 1995). For example, research estimates that spillover effects from R&D in the United States and Japan in 1990 may have boosted output in developing nations by up to US\$20 billion (Coe et al. 1995).

Taking advantage of spillover still requires some R&D capacity, and persons with the required skills, if technology and knowledge from another nation is to be absorbed and applied (Arnold & Bell 2001). Not all nations need to be at the cutting edge of global technological advances, but every nation needs the capacity to adapt

Box 7.3.1 Science and technology indicators – data availability

Available data report that R&D expenditure in the Tropics is substantially less than the Rest of the World. While this is undoubtedly the case, research suggests that reported data for many developing nations is likely to underestimate the true level of spending (Urama et al. 2010). This is because, unlike in developed nations where there is a strong focus on collecting data for science and technology indicators, many developing nations do not routinely collect and manage this information. Contributing factors often include a lack of suitably trained personnel as well as organisational priorities and limitations. For example, many institutions, ministries and organisations in tropical nations – particularly in Africa, Oceania and the Caribbean – do not have a culture of recording these types of data.

Although the coverage of tropical nations for which R&D data are available may be poor, the nations that are reported account for around 80 to 85% of GDP in the Tropics. Further, as no time series data are available for most African, Middle East, Caribbean and Oceanic nations, trend analysis for these regions is not possible.

Data are available for some nations in these regions, though of the 75 nations in the above four regions, sufficient data for time series analysis are only available for 10, suggesting that any analysis based on the available data is unlikely to be representative of regional activity.

This lack of data is recognised as a constraint to effective policy development and, in many regions, initiatives are in place to improve reporting. For example, the African Union, the New Partnership for Africa's Development (NEPAD) and UNESCO have developed Africa's Science and Technology Consolidated Plan of Action as a critical step towards addressing this lack of data and information (see Box 7.3.2).

In Oceania data are only available for the two largest regional economies, tropical Australia and the United States (Hawaii) which, as developed nations, are not representative of the broader region. Despite the lack of data for Oceania there are a number of regional bodies providing scientific leadership and research capacity throughout the region (see Box 7.3.2).



Image: James Cook University.

and understand global technologies for local needs. It is suggested that tropical nations should prioritise R&D efforts towards 'creative imitation' rather than producing new knowledge (Arnold & Bell 2001). Some tropical regions have been extremely successful at this. The production of electronics and semiconductors throughout South East Asia is based on technology that came from Japan and the United States more than 30 years ago and has made a major contribution to the region's economic growth (Sachs & McArthur 2002).

There are, however, specific research and development questions which arise as a result of the climate, geography and history of the Tropics which cannot be answered by science and technology created outside the Tropics (Sachs 2000). Some products (e.g. cures for tropical diseases and pest-resistant tropical crops) could generate huge benefits for tropical nations, but have little impact in the Rest of the World (Arnold & Bell 2001). In the Tropics, where income per capita is well below that of the Rest of the World, limited 'capacity to pay' for regional-specific research can constrain the extent of regional R&D activity. In a study by the World Health Organisation, pharmaceutical companies reported they did not pursue research into new tuberculosis medications due to high investment costs and lack of commercial return (Blanc & Nunn 2000).

It is possible for developing nations to transition from simply being adopters of technology to become technology innovators (Sachs & McArthur 2002) The pharmaceutical industry in India, for example, has moved from one of duplicative imitation to being a world leader in pharmaceutical innovation (Kale & Little 2007). Recent legal changes have allowed India to move away from simply replicating medications for export, to widespread investment in new chemical entities and drug discovery with the potential for huge benefits for health and welfare.

Public and private expenditure

Trends in private R&D expenditure best illustrate the rapid geographical changes taking place worldwide in the distribution of R&D spending. In developing nations, R&D funding is dominated by public spending (Mani, 2010) but a growing share of R&D is being performed by the private sector. Increased private spending is considered desirable, as businesses tend to transform the results of research into products and processes more rapidly than government (Mani 2010). Multinational companies are decentralising research activities across the globe to both developed and developing nations (Zanatta & Queiroz 2007). The rationale for this strategy is that it can reduce labour costs and give companies access to local markets, human capital and natural resources. This shift has been rapid. In 1990, 95% of private R&D expenditure occurred in developed nations, but by 2002, this had dropped to 76% (Hollanders & Soete 2010).

In India, private R&D expenditure has increased from 18% to 28% of total R&D spending between 1991 and 2007 (Mani 2010). Even though public spending still dominates total R&D expenditure, it has remained somewhat constant (relative to GDP) during this period. Thus, increases in technology and development in India can largely be attributed to this increased level of private expenditure.

Public monies comprise most of the R&D expenditure (55%) in Brazil, despite private investment increasing marginally in the past 10 years (Cruz & Chaimovich 2010). In Cuba, the situation is the opposite; business investment in R&D has declined from 36% in 2001 to 18% in 2008. This has been attributed to greater science and technology capabilities emerging in other parts of Latin America, drawing private funding away from Cuba to other nations in the region such as Brazil and Mexico (Arxer 2010).

In China, private investment dominates R&D expenditure and its proportion increased from 60% in 2000 to 73% in 2008. Generous tax incentives for experimental development,

technological equipment and infrastructure have contributed to this growth in private sector investment (Rongping 2010) alongside more liberal national policies to encourage international investments (Zanatta & Queiroz 2007).

There are several key factors which influence where private investment in R&D activities occurs with multi-national companies in particular seeking new resources, markets and efficiencies (Zanatta & Queiroz 2007). Adequate infrastructure, economic stability, fiscal incentives, an accessible and qualified workforce and appropriate intellectual property rights will all affect a nation's ability to attract private investment in R&D (Zanatta & Queiroz 2007, Naim 2010). Tropical nations lacking in R&D who wish to expand and develop science and technology capability, will need to undertake a wide range of measures to create an adequate environment to attract and promote business R&D investments.

Looking forward

There is no doubt that ongoing R&D investment in the Tropics is important for future development in this region. Partnerships between governments, the private sector and research universities will be essential for ongoing innovation in the Tropics. For poorer nations, regional approaches may be necessary to facilitate and manage R&D activities more effectively. Additionally, for increased R&D spending to be effective, investments in human capital and research infrastructure are essential.

Box 7.3.2 Regional approaches to research and development

Throughout the Tropics, regional approaches to R&D are helping to fill statistical gaps and develop research programs. Two such programs include "Africa's Science and Technology Consolidated Plan of Action" and the "Secretariat of the Pacific Community".

Africa

Many African nations have no record of the share of economic activity directed to R&D (Urama et al, 2010). Weak investment in R&D was identified as a potential risk to ongoing economic and social development and, to address this, the African Union (AU) and New Partnership for Africa's Development (NEPAD) have developed the Science and Technology Consolidated Plan of Action 2008–2013 (CPA) (African Union 2005). The CPA, adopted in January, 2007, articulates a commitment to collective actions to develop and use science and technology for the socio-economic transformation of Africa, and its integration with the global economy. Alongside the CPA, the African Ministerial Council on Science and Technology (AMCOST) was established as the overall governance structure for implementing the Plan. AMCOST is funded from donors and contributions from member nations.

A key objective of the CPA is to increase R&D expenditure to be at least 1% of GDP, as endorsed by the Executive Council of the African Union in the Khartoum Decision (EX.CI/Dec.254 (VIII)) in 2006.

Another initiative, arising from the CPA, the African Science, Technology and Innovation Indicators Initiative (ASTII) published the first African Innovation Outlook in 2010 which provides, in many cases the first record of many science and technology indicators for African nations (African Union 2010). According to the Outlook, only South Africa, Uganda and Malawi recorded research intensity above 1%. Other African nations ranged between 0.02% and 0.5%.

The CPA outlines flagship R&D programmes in four areas: biosciences; water; materials science and manufacturing; and information and communication technologies. The CPA also recommended coordinated funding for science, allowing nations to set their own research priorities, rather than donor organisations and nations. The African Union Research Grant Programme was established in 2008 and is responsible for coordinating research funding from a wide range of donors to answer key research and technology questions from member nations.

Although the CPA has been criticised for not achieving all of its objectives (Nordling 2010), it has brought science and technology

to the attention of both donors (private organisations, NGOs and international aid organisations) and African politicians, and has led to the development of other new programs and given individual science ministries guidance and direction to further science and technology in Africa. The CPA expired in 2013 but many programs which have arisen from the plan (e.g. AMCOST, ASTII and the African Union Research Grant Programme) will continue into the future.

The Pacific

Small island nations in the Pacific face a number of unique challenges, including how to manage rising sea-levels, saltwater intrusion, destructive storms and limited land resources. Solutions to these problems will require appropriate policy development, investment in R&D, and local capacity building.

Available data (or lack of it) suggests there is little to no investment in R&D in these nations, even though a number of organisations are known to be coordinating and funding a range of activities which small nations may not be able to afford (Turpin et al. 2010). Among these, the SPC plays a key role in developing science and technology in the region.

The SPC was the first regional scientific and development organisation in the Pacific. Established in 1947, its key objective is to deliver priority work programs to a number of member nations and territories to develop professional, scientific, technical, research and management capacity (SPC 2007). Funded largely through international aid from Australia, New Zealand and the European Union, the SPC model has been successful in the region, with a number of positive outcomes in agricultural research, marine fisheries, and social research focussing on women, youth and culture.

This regional approach to R&D may be effective in addressing knowledge and technology needs as well as fostering collaboration across the region. To achieve regional collaboration and developmental outcomes however, wide consultation with governments and other stakeholders is necessary to truly understand the R&D needs of each nation (Perera & Lamberts 2012). As a first step, basic science and technology statistics need to be generated so this region can become more visible to global science.





South Pacific.
Image: Pierre Lesage

Tertiary enrolments and graduates in science and engineering

Innovation, research and technology require more than just funding to drive development. People with appropriate skills are needed to create, adapt and use technology and knowledge. Higher (tertiary) education is vital for equipping people with the necessary skills and knowledge to contribute to advancement of science and technology in the Tropics.

Higher education produces skilled graduates who will contribute to a competitive workforce and develop the research capability necessary for innovation and consequently, development. Enrolments in tertiary education represent inputs to the research, development and innovation process. Not all students will go on to be involved in science and technology but they provide an indicator of growth in the knowledge and innovation capacity of an economy.

The number of people pursuing higher education has increased substantially. In 1970, there were less than 30 million students enrolled in tertiary education worldwide. This number increased to more than 150 million by 2007. Learning and innovation are seen as key to the development of nations and economies. Given the Tropics is home to a number of developing economies, investment in higher education will be important for future progress in this region.

Trends

Enrolments in tertiary education have increased in the Tropics and the Rest of the World over the past 10 years (see Figure 7.3.1). However, fewer people attend universities in the Tropics than the Rest of the World and the average rate of increase of enrolments in the decade to 2010 has been slightly lower in the Tropics (5%) than the Rest of the World (6%).

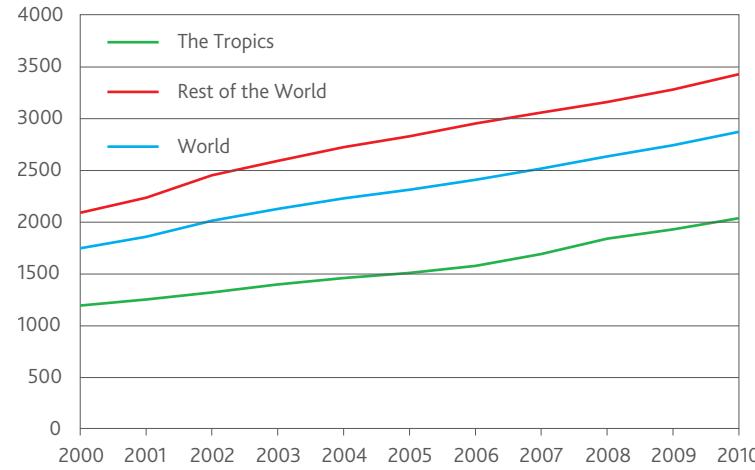
The number of people enrolled in tertiary education has increased across all regions of the Tropics in the past decade (see Figure 7.3.2). This global pattern is considered to be a result of the elimination of legal and economic barriers (e.g. gender, race and cost) (Shin & Harman 2009) and

indicates that a wider group of socio-economic classes are now accessing higher education.

Central & Southern Africa has the lowest rate of university enrolment in the Tropics. However, enrolments in this region increased by 150% in the decade to 2010. Multiple factors have contributed to student increases in Africa, including rapid population growth, rising levels of secondary education completion (Kritz 2013) as well as a vast increase in the number of public and private universities (Kingsley 2010). This rate of increase is second only to the Caribbean where data is reflecting low total population growth rather than large increases in tertiary enrolments. Population growth in Cuba in particular has been declining since 2002 and has shown negative growth since 2008.

A more direct measure of human capital for science and technology development is the proportion students graduating with qualifications in science and engineering. Data on graduates from

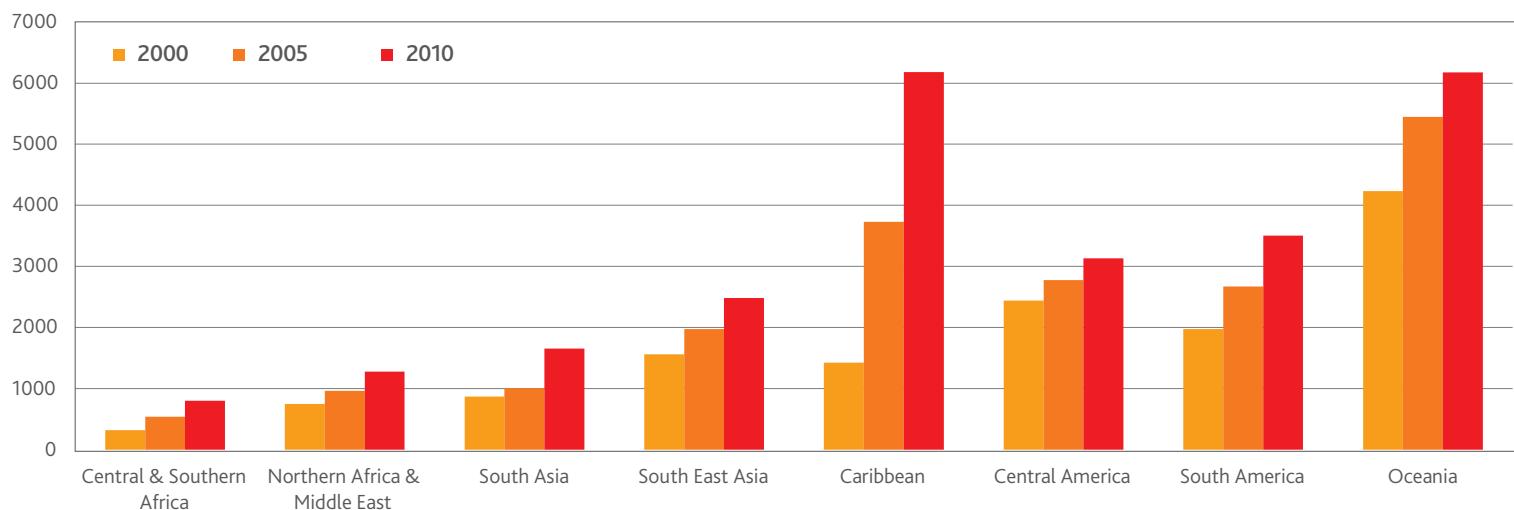
Figure 7.3.1 Tertiary education enrolments per 100 000 population



Source: UNESCO (2013), State of the Tropics project.

tropical universities are sparse, however some trends emerge. An average of 24% of all reported tertiary graduates from the Tropics between 2000 and 2010 studied in the science and engineering fields. However, only 10% of all science and engineering graduates worldwide came from institutions in the Tropics. Graduates from the Tropics studying science and engineering increased in the decade to 2010 from less than 100,000 to almost one million. Evidence also suggests that not only the total numbers but also the rate of increase are underestimated due to some data not being available (Gereffi et al. 2008). The rate of increase in the Rest of the World has been lower, even though total tertiary enrolments has grown faster, with total reported science and engineering graduates per annum increasing from 1.8 million to 3.1 million in the ten years to 2010.

Figure 7.3.2 Tertiary enrolments per 100 000 population, the Tropics



Source: UNESCO (2013), State of the Tropics project.

Note: These estimates do not include India, China or Hong Kong.

Transition to a knowledge based economy

There is no doubt that participation in higher education has been increasing worldwide. Additionally, there is broad consensus that human capital is an important determinate of productivity, improved living standards and other economic and social outcomes (De la Fuente & Ciccone 2002). In an increasingly globalised world, with an emerging knowledge-driven economy, university graduates represent a significant investment into human capital (Asian Development Bank, 2007). Economic advantage is coming less from abundant natural resources or cheap labour and more from technical innovations and the competitive use of knowledge (Salmi 2001).

According to the OECD, "knowledge based economy" is an expression to describe trends in advanced economies towards greater dependence on knowledge, information and high skills, and the increasing need for ready access to all of

these things by the business and public sector (OECD 2005). Some of the key characteristics of a knowledge based economy are that learning is increasingly central for both people and organisations; learning organisations are increasingly networked; and initiative, creativity, problem solving and openness to change are increasingly important skills (Houghton & Sheehan 2000).

Many tropical nations are investing in initiatives to bring about a knowledge based economy. For example, Malaysia has increased government spending in tertiary education resulting in a 25% improvement in tertiary enrolments. They have re-oriented training and education systems to prioritise the sciences and have encouraged university-industry partnerships (Asian Development Bank 2007).

The increasing number of tertiary enrolments in institutions in the Tropics is a strong indication that this region can move towards a more

knowledge based economy. By raising the level of education and its quality, and increasing graduate numbers, tropical nations may be able to stimulate innovation, broaden the diversity of products and services, and increase returns from capital assets through more efficient allocation and management (The World Bank 2008). However, even though investment in information technology is increasing in tropical regions (e.g. most recently Africa: The Economist 2013) many tropical nations are still a long way from relying on knowledge and technology for income and growth.

Student mobility, brain drain and the tropical diaspora

Students and graduates are highly mobile, particularly from the Tropics. In 2000, 19 of the 20 nations with the highest rate of skilled migration were in the Tropics³. In 2010, 3.6 million students were enrolled abroad. East Asia and Oceania provide the largest source of international students

with the largest number (17%) originating from China. Around 6% of all students in central Asia and 5% of all students from sub-Saharan Africa study outside of the region (UNESCO 2013). Half of all of Colombia's science PhDs work abroad and an estimated 47% of Ghanaian doctors work in other nations (Kearney 2009).

Since the 1960s, there has been concern about rising levels of "Brain drain", initially in developed nations like the United Kingdom but more recently, the concern has been from lower and middle income nations (Docquier & Rapoport 2011) where it is a much bigger issue in a relative sense. Brain drain refers to well educated, highly skilled people leaving areas of low income to seek higher incomes and standards of living elsewhere, and students who move abroad to study but do not return upon achieving their qualification (Chien & Chiteng Kot 2011).

In sub-Saharan Africa, brain drain is a large problem and many nations lack the human capital required for progress. In 2007 the African Union established the Mwalimu Nyerere African Union Scholarship Scheme which is designed to enable African students to study science and technology at higher education institutions on the continent⁴. This program facilitates mobility of students while also supporting human capital to stay in the region.

Brain drain may not always be negative. Technology and knowledge can move both outward and inward. Since 1990 the diaspora⁵ of developing nations has doubled in size and, as more highly skilled individuals migrate than low skilled individuals, the diaspora is generally well educated. This group of people can provide an important technological resource for their home region. Migrants returning to a nation with assets such as entrepreneurship, technology, marketing knowledge and investment capital can have large economic and technological benefits (World Bank 2008).

Looking forward

A key challenge for nations and higher education institutions in the Tropics will be the balance between developing high quality, world class universities and improving access to higher education. In rich, developed economies, policymakers are able to facilitate funding for both quality and quantity in their higher education systems. The USA for example, can fund world-leading universities as well as support thousands of smaller, cheaper, community colleges. Middle to low-income nations in tropical regions face a trade-off between widening access and maintaining quality (Healy 2013).



³ The top 20 countries with the highest emigration rates of university graduates as a percentage of the national high skilled labour force in 2000: Haiti (83.4); Sierra Leone (49.2); Ghana (44.7); Kenya (38.5); Laos (37.2); Uganda (36); Eritrea (35.2); Somalia (34.5); El Salvador (31.7); Rwanda (31.7); Nicaragua (30.2); Hong Kong (29.6); Cuba (28.8); Sri Lanka (28.2); Papua New Guinea (27.8); Vietnam (27); Honduras (24.8); Croatia (24.6); Guatemala (23.9) from Docquier F, Rapoport H (2011)

⁴ The Accra Declaration on GATS and the Internationalization of Higher Education in Africa can be found at <http://www.che.ac.za/documents/d000060/AccraDeclaration-Final.pdf>.

⁵ In this case, "diaspora" refers to the segment of people who live and work outside their homeland but maintain cultural connections

Scientific and technical journal articles

Economic growth, social development, and environmental management are closely linked to the application of scientific knowledge. Articles published in scientific and technical journals represent the latest theoretical research and experimental results in their field. Journal articles are the principal way that scientists and researchers communicate with one another and share their research findings. As such, the number of articles published is an output indicator of research and technology activity being undertaken in an economy, and represents new contributions to knowledge. Research activity represents an investment in the future, whether it is for environmental, social, or economic purposes.

It is widely acknowledged there is an unbalanced distribution of scientific activity between the

developing and developed world (Annan 2003). Geographic disparity between the Tropics and the Rest of the World is common in both health and ecological research (Jentsch & Pilley 2003, Stocks et al. 2008). Recently however, governments in the developing world, including many in the Tropics, have set out to develop more knowledge intensive economies by investing in education, science, technology and innovation, information and communication infrastructure, and adapting the policy and regulatory environment (Asian Development Bank 2007).

Global patterns of scientific progress and quality, and how they affect the tropical world can be important indicators of scientific, economic and social development (Gálvez et al. 2000).

Trends

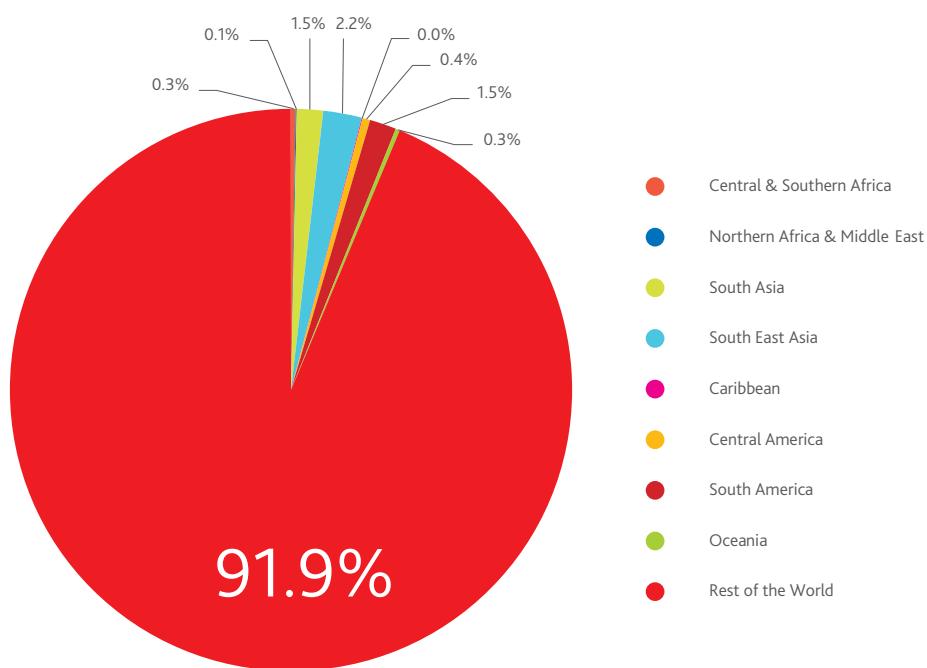
Scientific and technical journal articles refer to the number of scientific and engineering articles published in the fields of physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences. These data are not representative of all scientific and technological outputs from work conducted in the Tropics; they are publications where one or more authors are affiliated with an institution located in the Tropics.

Where time series exist, tropical nations account for only 5% of scientific and technical journal articles published worldwide since 1990. This proportion has been increasing, with research from the Tropics responsible for more than 6% of all scientific and technical publications in 2009 (see Figure 7.3.3) compared with 3.3% in 1990. Nearly 45% all articles authored in tropical institutions are attributed to Brazil and India.

Article output worldwide between 1990 and 2009 grew at an average rate of 2.7% per annum. Growth of articles from the Tropics was more than double the Rest of the World (2.4%) at 6% per annum. This steady improvement is being driven by South Asia, South East Asia, South America and Central America which have all shown dramatic increases in science and technology journal article output, even relative to population increases in those regions (see Table 7.3.2). The rate of outputs from Central & Southern Africa and Northern Africa & Middle East has actually declined.

The number of articles from South East Asia and South America has more than tripled in the past two decades. These trends have been driven largely by individual countries such as China (including Hong Kong), Singapore and Brazil, which have increased their output during this time substantially (see Figure 7.3.4). These regional patterns, driven by strong and growing economies represent an investment by those nations in science and technology, research and the tertiary education sector.

Figure 7.3.3 Total number of scientific and technical journal articles, 2009



Source: NSF (2011), State of the Tropics project.

In Brazil, the increase in journal article output has been correlated with a growing number of doctoral graduates (Cruz & Chaimovich 2010). China has also been investing in higher education, research and technology development. China's total article output is now third only to the USA and Japan and likely to surpass both in the near future (Rongping 2010). India's recent rise in journal article output is fuelled by increased investment in pharmaceutical research as well as a sharp rise in international collaborations, particularly with South Korea and Japan (Mani 2010).

The disparity between the Tropics and the Rest of the World in terms of output in journal articles may also be exacerbated by the way scientific journals are measured and reported. There is a bias towards English language journals and those published in North America and Europe. Small, low impact, local journals published in local languages are unlikely to be included in worldwide databases. Conversely, it is these journals which are likely to publish work most relevant to the Tropics, addressing local issues (Galvez et al. 2000).

Collaborative science in the Tropics

The world has become more connected. Knowledge and research, like economies and markets, have become global. According to the National Science Foundation, co-authorship worldwide rose from 40% of articles published in 1988 to 67% in 2010, with international co-authorship increasing from 8% to 24%. This move to international collaboration is driven by factors such as lower cost communication and air-travel, increased use of information technology, national policies encouraging international collaboration and the increased mobility of students (Ware & Mabe 2009).

Research collaboration plays a central role in the generation of knowledge as these partnerships will share scientific goals and exchange ideas and expertise to address specific problems. International collaboration can help address those challenges which transcend national borders such as climate change, global health, food security,

Table 7.3.2 Scientific and technical journal articles published per 100,000 population

	1990	1995	2000	2005	2009
Tropics	0.81 (16,053)	0.83 (18,157)	1.05 (25,182)	1.40 (36,708)	1.75 (48,942)
Central & Southern Africa	0.44 (1,762)	0.33 (1,535)	0.29 (1,539)	0.26 (1,584)	0.30 (2,035)
Northern Africa & Middle East	0.59 (474)	0.52 (487)	0.38 (413)	0.36 (446)	0.35 (488)
South Asia	0.98 (5,683)	0.90 (5,697)	0.91 (6,152)	1.20 (8,669)	1.54 (11,663)
South East Asia	0.51 (2,831)	0.52 (3,170)	0.91 (6,068)	1.53 (10,886)	2.29 (17,160)
Caribbean	0.82 (236)	1.01 (311)	1.21 (395)	1.13 (386)	0.98 (347)
Central America	0.99 (955)	1.54 (1,659)	2.12 (2,483)	2.61 (3,281)	2.59 (3,433)
South America	1.17 (2,574)	1.52 (3,654)	2.47 (6,459)	3.42 (9,624)	3.99 (11,771)
Oceania	19.55 (1,538)	19.02 (1,644)	17.59 (1,673)	17.46 (1,833)	17.98 (2,045)
Rest of the World	15.62 (484,391)	16.19 (541,224)	16.89 (597,529)	17.88 (661,870)	18.88 (724,193)
World	9.37 (475,365)	10.21 (564,137)	10.61 (629,903)	11.23 (709,431)	11.89 (788,333)

Source: NSF (2012), State of the Tropics project.

biodiversity, water security, energy security, and population growth. The increase in international collaboration will have positive outcomes for research and development in the Tropics. It removes the need for "fly in fly out" researchers from non-tropical areas and encourages greater integration with local scientists and institutions and therefore, more likely adoption of new technologies and advancements (Eddleston 1999).

Previously, collaborations between poorer tropical nations and wealthier nations in higher latitudes have been characterised by an

imbalance in terms of access to information, funding, training, conferences and publishing opportunities, as well as the disproportionate influence of non-tropical partners in project administration and budget management (Jones & Blunt 1999). However, many tropical countries are now home to exceptional research institutions that are not only well resourced and staffed but also politically influential.

Building science and technology capacity in the Tropics

Many scientific and technical challenges facing the Tropics are unique. To meet these challenges, nations and institutions in the Tropics will need to continue to build capacity and invest in science and technology.

Traditional capacity building activities conducted by international organisations can be counterproductive to the development of a sustainable research program in terms of inappropriate research priorities, inhibiting knowledge transfer between scientists, and not facilitating the necessary communication pathways to policy development (Wolffers et al. 1998). Aid and donor programs often favour "seed" funding initiatives which fail to provide the long term, reliable funding required to develop and sustain research communities in terms of infrastructure and personnel in the Tropics (Ware & Mabe 2009).

Establishing and maintaining centres of scientific excellence in key tropical areas and "twinning" organisations between the developed and developing world are two techniques which have been used and are considered more successful than simply providing one-off capacity building support (Eddleston 1999, Jones & Blunt 1999).

Information flow – to, from, and between tropical nations

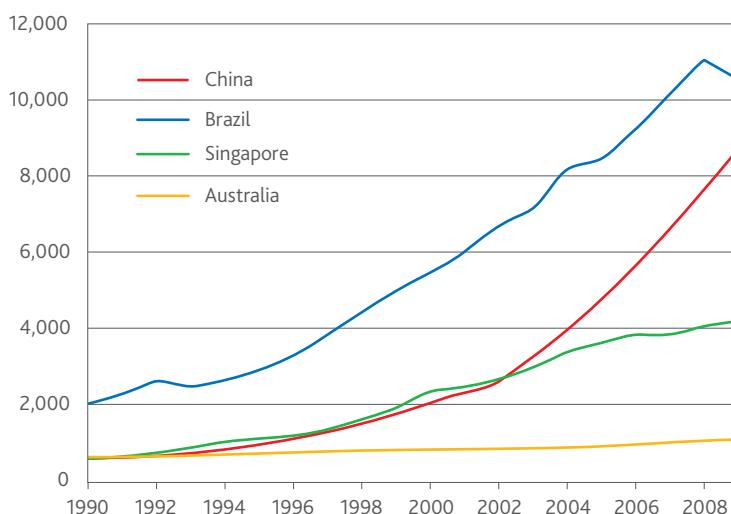
Nations in the Tropics face many problems including poverty, inadequate drinking water, high illiteracy, high foreign debt and a heavy disease burden. In order for science and technology to play a role in alleviating some of these stressors access to knowledge and information must be maintained and improved.

Improving access to information technology and online journal archives is a technique used to

bridge the divide between developing nations and the more scientifically prolific economies in the Rest of the World (Nchinda 2002). Two programs: the Health InterNetwork Access to Research Initiative (HINARI)⁷; and the Global Online Research in Agriculture (AGORA)⁸ have been developed to provide free or highly discounted subscription access to major online journals for developing countries. These programs have been successful in improving access to published information for some countries, however exclude countries like India, China and Brazil so are unlikely to have a major impact on the total number of articles published from tropical regions (Chan & Costa 2005).

The above initiatives improve information flow to the Tropics, but do not necessarily facilitate or assist tropical researchers to share and publish research arising in the Tropics. Unlike most of the Tropics, the tropical regions of Africa and the Middle East have shown no improvement in scientific output over the past two decades. Several reasons have been proposed for why Africa makes such a small contribution to the scientific and technical literature including: perceived poor quality by world standards; communication barriers, brain drain; inadequate access to publication media; and poor management of some smaller less well known journals (Britz & Lor 2003).

Figure 7.3.4 Number of scientific and technical journal articles published for key tropical countries*



Source: NSF (2012), State of the Tropics project.

*Corrected for tropical population

⁷ Health InterNetwork Access to Research Initiative - <http://www.who.int/hinari/en/> HINARI Programme set up by WHO together with major publishers, enables developing countries to gain access to one of the world's largest collections of biomedical and health literature. More than 8,500 journals and 7000 e-books (in 30 different languages) are now available to health institutions in more than 100 countries, areas and territories benefiting many thousands of health workers and researchers, and in turn, contributing to improve world health.

⁸ Access to Global Online Research in Agriculture - <http://www.aginternetwork.org/en/> The AGORA program, set up by the Food and Agriculture Organization of the UN (FAO) together with major publishers, enables developing countries to gain access to an outstanding digital library collection in the fields of food, agriculture, environmental science and related social sciences.

⁹ Thomson Reuters Institute of Scientific Information Web of KnowledgeSM Essential Science IndicatorsSM <http://apps.webofknowledge.com>

Scientists, health workers and engineers in the Tropics would benefit from information generated in their own country or region. Future development in this area will require international databases to include local publications – currently they are dominated by research from Europe and North America, much of which has little relevance to the Tropics.

Looking Forward

The growing contribution of tropical institutions to the global scientific literature and recognition of tropical institutions as leaders in various fields will ensure that science and technological challenges particular to the Tropics continue to be met. This will require significant capacity building and investment in science and technology in tropical regions from both public and private sectors. Partnerships between tropical and non-tropical institutions will continue to be beneficial and greater investment in and awareness of peer reviewed journals which focus on tropical regions and nations will be needed. Incentives for qualified scientists to live and work in the Tropics will also be important for sustained growth in science and technology.

Box 7.3.3 Citations – quality and quantity of scientific and technical journal articles

The quality of scientific research is measured in a number of ways; the most widely used method being citation rates (Coryn 2004). Citations occur when a researcher refers to another researcher's work in a publication. Highly cited research is considered meritorious or significant.

The Tropics produces relatively low numbers of scientific and technical journal articles but research authored in tropical regions has a citation rate (number of citations per paper) on par with the Rest of the World. According to the Thomson Reuters Institute for Scientific Information (ISI)⁹, in the decade to 2012, tropical nations had a citation rate of 13 citations per article published, slightly higher than the Rest of the World (12 citations per paper). There is some debate as to the usefulness of citations

as an indicator of scientific quality due to the ISI's bias towards US journals, as well as only recording publications written in English (Coryn 2004, Aksnes 2003). Additionally, papers might be highly cited because they have been discredited (Galvez et al. 2000), or due to some authors' over-citing their own work (Aksnes 2003). Additionally, only peer reviewed, published articles are included in this index. It does not include 'grey literature' such as reports from governments and non-government organisations.

Citation rate is considered the best measure of research quality available, and the data indicates that although the bulk of scientific and technical journal articles are produced in non-tropical regions, the quality of research from the Tropics is as good as the Rest of the World.



Scientific journals. Image: Robert Cudmore.

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Engineering Students, Thailand.
Image: Gerhard Jörén, World Bank.



KHAHOMEX

VĂN ĐỒ



Essay 4

Tropical underdevelopment – is it a thing of the past?

Dennis Trewin, AO.

Dennis Trewin was the Australian Statistician and head of the Australian Bureau of Statistics from July 2000 until January 2007. Prior to that he was Deputy Australian Statistician and, from 1992 to 1995, Deputy Government Statistician in New Zealand. He has recently been working as a statistical consultant on assignment with a range of countries and with the UN, OECD and World Bank. His most recent assignments have been in Indonesia, Fiji and Sweden.

Dennis has held a number of other positions such as an Australian Electoral Commissioner, an Associate Commissioner at the Productivity Commission for the study into the Not for Profit Sector, and a Trustee and Board member for the Australian Reward and Investment Alliance. He has been Chairman of the Advisory Board of the ARC Centre of Excellence for Coral Reef Studies. He has been Chairman of the Policy and Advocacy Committee of the Academy of Social Sciences of Australia. He is also an Adjunct Professor at Swinburne and Curtin Universities, a Council Member of the University of Canberra, and a Director of the Australian Mathematics Trust. He has been recognised as an Officer in the Order of Australia and received a Centenary Medal for his contribution to statistics.

Internationally, Dennis has been President of the International Statistical Institute. He was Chairman of the Global Executive Board for the 2005 round of the World Bank's International Comparison Program.

Urbanisation, Vietnam.
Image: Tran Veit Duc, World Bank.

Tropical underdevelopment – Is it a thing of the past?

Dennis Trewin

Introduction

In his 2000 paper on Tropical Underdevelopment, Jeffrey D. Sachs (Sachs 2000) concluded that there was a significant historical difference between temperate and tropical regions in terms of economic growth rates and per capita incomes. His hypotheses were based on a range of quantitative models and he suggested this historical divide would persist into the near and far future. 'The income gap has also been amplified because poor public health and weak agricultural technology in the tropics have combined to slow the demographic transition from high fertility and mortality rates to low fertility and mortality rates. The analysis suggests that economic development in tropical ecozones would benefit from a concerted international effort to develop health and agricultural technologies specific to the needs of the tropical economies' (Sachs 2000). The time period used for much of his analysis

ended at 1995 and correctly represented the situation at that time. He noted that tropical countries had grown more rapidly in the years leading immediately up to 1995 (per capita GDP both temperate and non-temperate regions had grown at 2.3%)¹. He thought, however, that this growth should have been greater, given the natural tendency of per capita incomes to converge as a consequence of global trade, technology diffusion and capital flows from richer countries. You would expect the tropical countries to grow faster than the temperate zone but he believes 'this tendency towards convergence is muted, if not eliminated altogether' (Sachs 2000, pg. 9). He also highlighted the relatively poor performance of many African and Latin American countries. I have used 1995 as the starting point for my analysis wherever possible. That period has not always been available in the data used for the State of the Tropics Report so I have used a similar period

in these cases. Sometimes, I have also referred to data from more distant periods to emphasise the changes to tropical countries. It should be noted that I am a statistician not an economist and I have taken a statistician's perspective to this analytical essay.

The economic growth rates for the Tropics have greatly exceeded those for the Rest of the World since 1995, probably more so than expected by Sachs. Improvements have also occurred in a range of other progress indicators. The main purpose of this paper is to provide some explanation of the arguably surprising strength of this economic growth. I have primarily used the indicators in the State of the Tropics Report to illustrate my points.

¹ All references to GDP in the text and tables are to real GDP ie nominal GDP adjusted for the impact of price increases

Table E4.1 Average annual change in real GDP (%)*

	1980-1985	1985-1990	1990-1995	1995-2000	2000-2005	2005-2010	1980-2010	1995-2010	2000-2010
Tropics	2.1%	3.9%	4.6%	3.6%	4.8%	5.8%	4.1%	4.7%	5.3%
Central & Southern Africa	0.9%	3.3%	1.1%	3.8%	5.5%	6.5%	3.5%	5.3%	6.0%
Northern Africa & Middle East	-3.2%	3.4%	2.6%	3.3%	4.3%	3.6%	2.3%	3.7%	4.0%
South Asia	4.9%	5.7%	5.9%	5.6%	7.1%	8.3%	6.3%	7.0%	7.7%
South East Asia	4.5%	7.5%	8.2%	3.4%	6.1%	6.5%	6.0%	5.3%	6.3%
Caribbean	0.3%	2.3%	3.7%	4.7%	4.0%	4.6%	3.3%	4.4%	4.3%
Central America	1.7%	1.4%	1.5%	4.9%	1.8%	2.6%	2.3%	3.1%	2.2%
South America	0.9%	2.1%	3.3%	1.7%	3.1%	4.5%	2.6%	3.1%	3.8%
Oceania	4.1%	3.7%	3.2%	3.9%	3.3%	2.1%	3.4%	3.1%	2.7%
Rest of the World	3.4%	3.6%	2.7%	3.7%	3.1%	2.7%	3.2%	3.2%	2.9%
World	3.2%	3.6%	3.0%	3.7%	3.4%	3.3%	3.4%	3.5%	3.4%

Source: World Bank (2013), State of the Tropics project

*Measured at purchasing power parity in constant 2005 international dollars.

To be clear, the objective of the essay is not to criticise Sachs' significant paper; rather, it is to use Sachs' paper as a base and to provide some analysis of the main driving forces for the relatively strong improvements in the Tropics since the publication of that paper. In particular I will analyse Sachs' hypotheses to explain the lower growth rates in the Tropics to assess whether changes in the areas addressed by the hypotheses have led to better economic performance. I will also look at other indicators we think may be important to explain the extraordinary economic performance of the Tropics.

A review of Sachs' main findings

Sachs' quantitative analysis showed that the growth rates for the Tropics were much lower than the temperate region over the period 1820 to 1995. Per capita incomes in the Tropics were correspondingly lower than the Rest of the World and the ratio decreased over time.

Sachs provided five hypotheses as to why this might be the case. These five factors related to technology development, technology productivity, innovation, societal dynamics and geopolitical factors.

(1) Technologies in critical areas are ecologically specific, especially in the areas of health and agriculture, but also construction, energy use, and some manufacturing processes. Such technologies do not easily transfer across ecological zones.

(2) Temperate zone technologies were more productive than tropical zone technologies in crucial areas of health, agriculture, energy utilisation, and military technology. It is likely these differences could not be overcome by altering existing temperate zone technologies.

Table E4.2 Annualised change in per capita GDP for selected period*

	1995 - 2010	2005 - 2010
Tropics	3.0%	4.1%
Central & Southern Africa	2.6%	3.8%
Northern Africa & Middle East	0.8%	0.3%
South Asia	5.6%	6.9%
South East Asia	3.9%	5.2%
Caribbean	3.2%	3.6%
Central America	1.6%	1.2%
South America	1.7%	3.3%
Oceania	0.6%	0.1%
Rest of the World	2.2%	1.8%

Source: World Bank (2013), State of the Tropics project

*Measured at purchasing power parity in constant 2005 international dollars.

Table E4.3 Change in Human Development Index between 1990 and 2010*

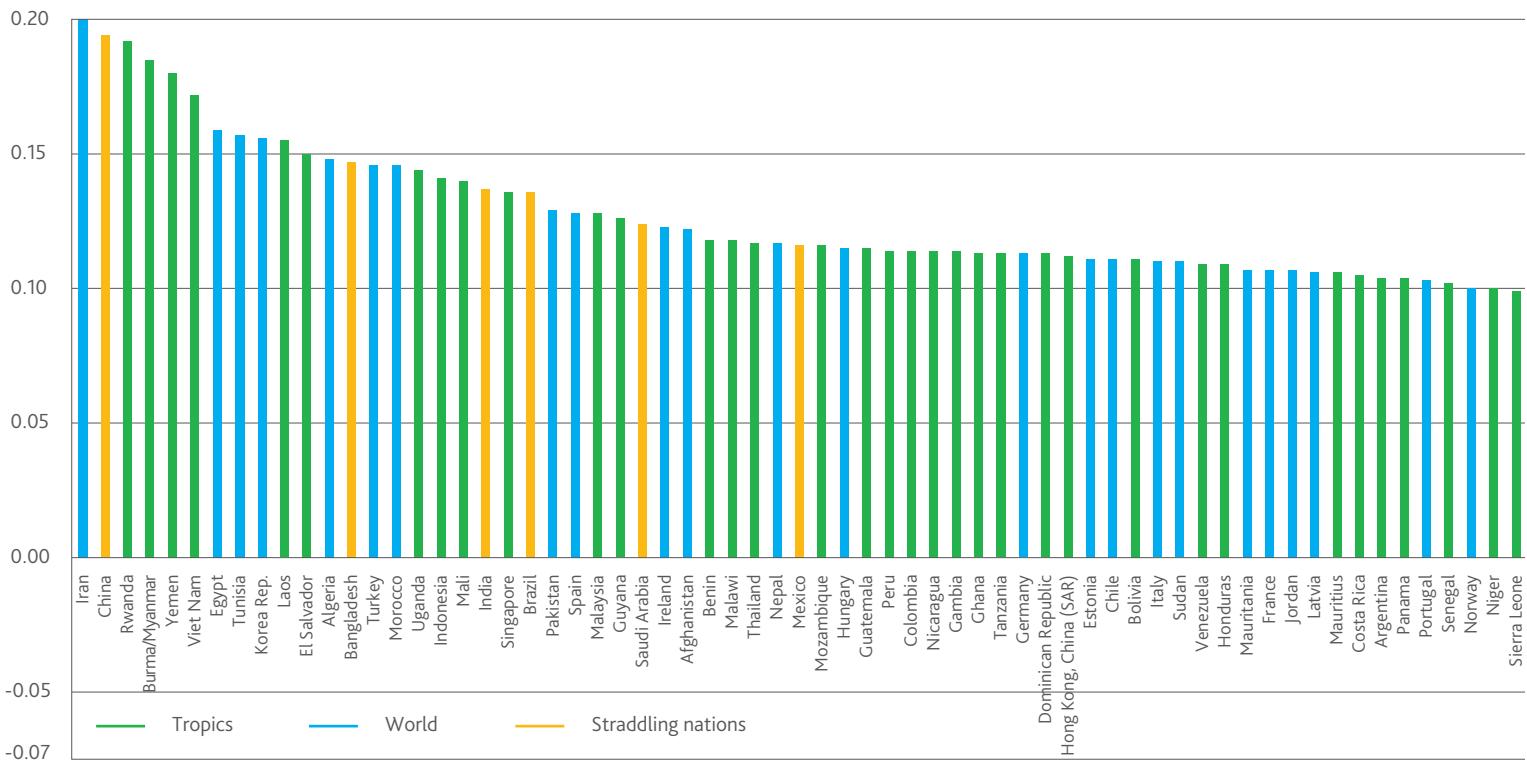
	Average of 1990 HDI	Average of 2010 HDI	Difference 1990-2010
Tropics (excluding straddling nations)**	0.48	0.58	0.10
Central & Southern Africa	0.38	0.45	0.07
Northern Africa & Middle East	0.37	0.50	0.13
South Asia	0.46	0.59	0.13
South East Asia	0.57	0.70	0.13
Caribbean	0.63	0.71	0.08
Central America	0.58	0.69	0.11
South America	0.60	0.71	0.11
Oceania	0.68	0.75	0.07
Oceania (Australia & USA omitted)	0.55	0.62	0.08
Rest of the World	0.69	0.76	0.08
Rest of World (including Australia and USA)	0.69	0.77	0.08
World	0.59	0.68	0.09
Straddling nations**	0.62	0.74	0.12

Source: UNDP (2014), State of the Tropics project

*Values are the average for nations with available data using State of the Tropics regions.

**Straddling nations include: Mexico, Brazil, Saudi Arabia, India, Bangladesh, China, Australia and United States (Hawaii).

Figure E4.1 Magnitude of change in Human Development Index between 1990 – 2010



Source: UNDP (2014), State of the Tropics project

- (3) Temperate zone innovation has been favoured strongly by larger and richer populations. Technological innovation has an increasing return to scale. Therefore, the larger, richer population in the temperate zone, which has been integrated in a global market since 1800, has strongly favoured innovation. This has probably amplified the gap between the temperate and tropical zones over the past 200 years.
- (4) Societal dynamics are different. The processes of urbanisation and demographic transition, among other societal dynamics, further amplify discrepancies in the development

process. Tropical regions have long lagged behind fast growing temperature regions.

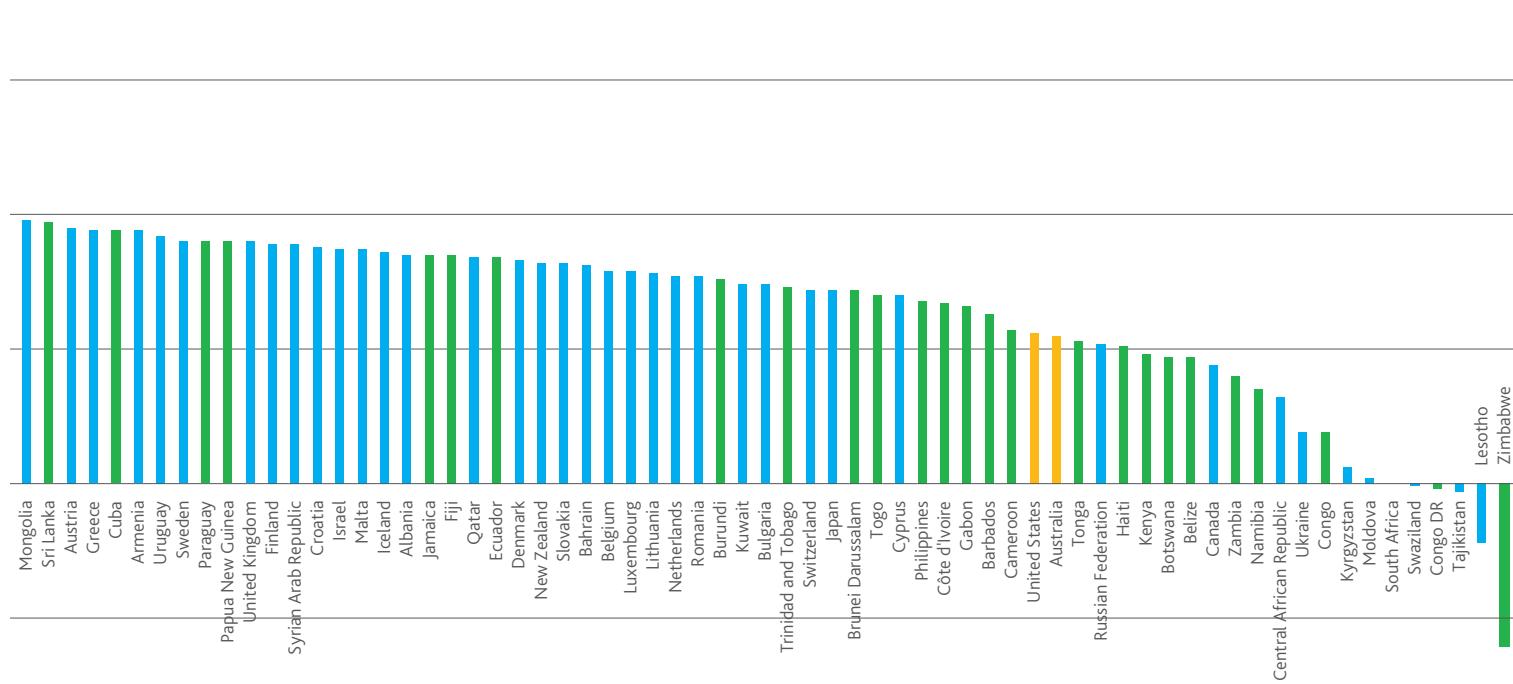
- (5) Geopolitical factors. Temperate zone imperial domination of tropical regions on the basis of superior military technology, and rich-country control of the institutions of globalisation – are further amplifiers. However Sachs believed their role was often exaggerated when not considered alongside the underlying technological, demographic, and urbanisation processes.

According to Sachs, 'If these hypotheses are broadly correct, then policy solutions for tropical underdevelopment will require a much greater

national and international focus on technological innovation directed at the problems of tropical ecology' (Sachs 2000 pg.4).

Overview of economic performance since 1995

How have the Tropics performed economically in more recent years? Over the period from 1995 to 2010, GDP in tropical nations grew at an annual rate of 4.7% compared with 3.2% for the Rest of the World (see Table E4.1). The fastest growing regions have been South Asia (7.0%), Central and Southern Africa (5.3%) and South East Asia (5.3%).



In fact, the rate of growth for these regions has accelerated in recent periods. This is also true for Latin America. Looking at the more recent 2005–10 period, it can be seen that the growth has been 5.8%, much higher than the 2.7% experienced by the Rest of the World (see Table E4.1). Of course, per capita incomes remain much lower – it will take many decades of higher growth to catch up.

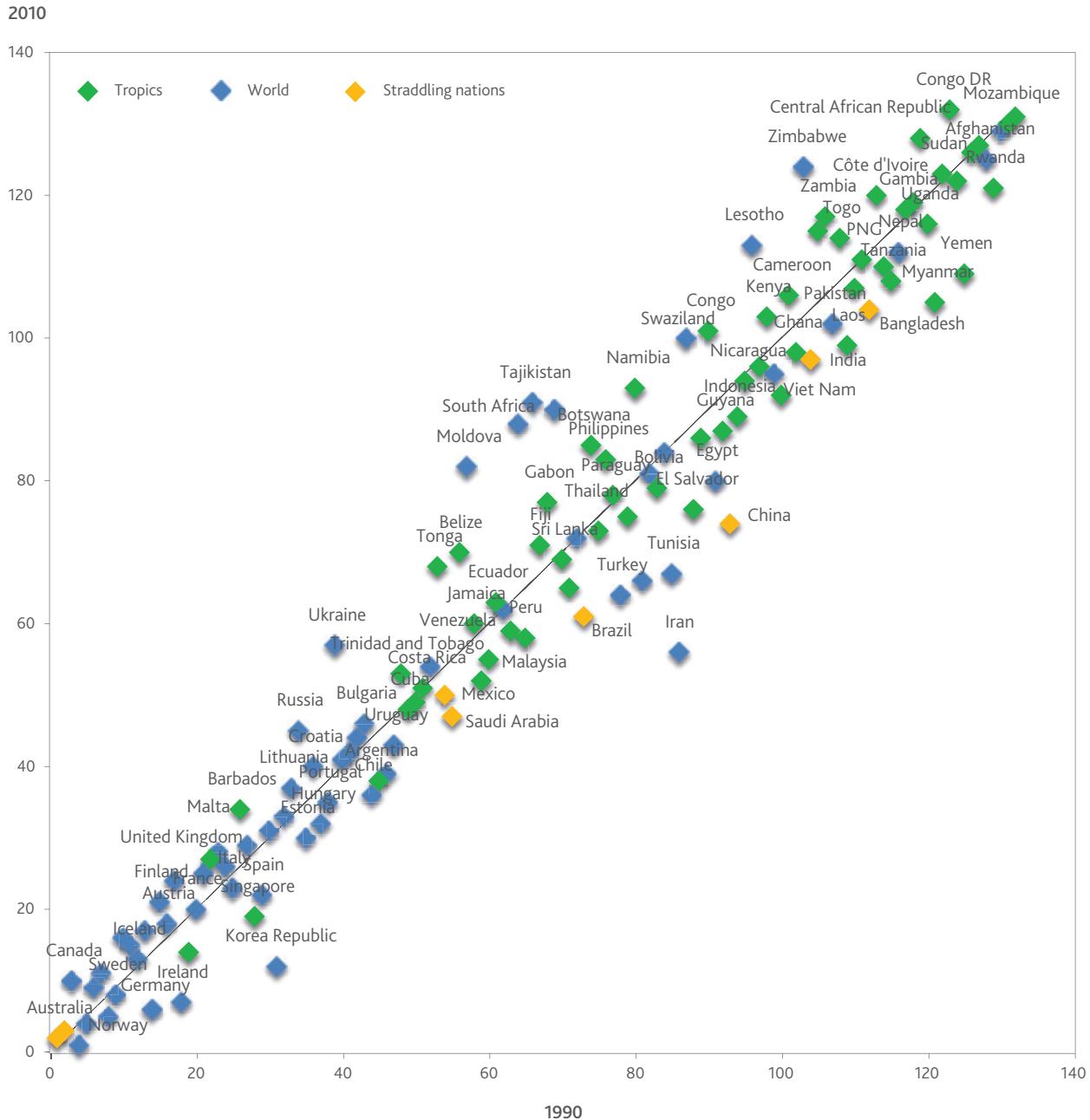
How does this compare with Sachs' analysis of earlier periods? His definitions of regions are not identical but are close enough to make comparisons valid. During the long period from 1820 to 1992, the per capita GDP of the temperate region grew at an annual average rate of 1.4 percent per year,

compared with 0.9 percent per year in the non-temperate region (dominated by tropical countries). Note that these are per capita measures so they will be lower than growth in GDP measures if there has been positive population growth. He also points out that the ratio of per capita GDP measures for temperate to non-temperate countries changed from 1.4 in 1820 to 4.5 in 1995.

Table E4.2 shows the comparisons for annualised growth rates for per capita GDP. On this measure, the Tropics are also growing much faster than the Rest of the World. Over the 1995 to 2010 period, the Tropics grew at 3.0% compared with 2.2% for the Rest of the World.

In more recent times, the growth in the Tropics has accelerated whereas it has gone in the opposite direction for the Rest of the World. Over the 2005 to 2010 period, the annualised growth in per capita GDP for the Tropics was 4.1% compared with 1.8% for the Rest of the World. This is much greater than the 0.9% annualised growth estimated by Sachs for the non-temperate region (which will be dominated by countries in the Tropics). Things have clearly changed although the performance by region is quite mixed. Differences between regions are explored later in the paper.

Figure E4.2 Human Development Index, 1990 rankings versus 2010 rankings



Source: UNDP (2014), State of the Tropics project.

This relative improvement for tropical countries is also true for a range of other progress indicators, some of which are summarised by the UNDP's Human Development Index (HDI) (UNDP 2014).² As can be seen from Table E4.3, the change in the HDI between 1990 and 2010 has been 0.10 (21%) for tropical countries (excluding those large countries straddling the tropical and temperate regions) compared with 0.07 (10%) for the Rest of the World.³ If you include the straddling countries, such as China, India and Brazil, the improvement would be 0.11. The regions showing the greatest improvement are South East Asia, South Asia and Northern Africa and the Middle East. The regional estimates in Table E4.3 include the straddling countries.

These findings are reinforced by the following two figures. In Figure E4.1, the countries with the greatest improvement in HDI scores are shown on the left. The tropical countries are shown in green and countries which straddle the Tropics are shown in yellow. There is a definite preponderance of tropical countries on the left hand side of the graph especially if the straddling countries are included (which have performed better on average). There is also some clustering on the right hand side. This latter group is dominated by poor performing African countries. The performance has been quite mixed in African countries – some have shown significant improvements, others have not. Figure E4.2 shows rankings rather than HDI scores. Countries falling below or to the right of the diagonal line improved their ranking. It is not as easy to see but the tropical and straddling countries are more likely to have improved their ranking.

Then and now: a comparison, a viewpoint, a changing landscape?

I will look now at the economic growth and development in the Tropics with specific attention to each of Sachs' five hypotheses. A number of indicators have been used to illustrate the way the tropical landscape has changed economically, socially and environmentally. I will look first at hypotheses (1), (2) and (3); it is convenient to

look at these hypotheses concurrently as they all relate to technology and transfer of technology. The relevant indicators are shown in italics and, for the first three hypotheses, they are as follows: foreign direct investment, research and development expenditure, mobile technology, internet, tertiary enrolments and scientific and technical journal articles.

The expectation is that *foreign direct investment (inflows)* should have increased as it is an effective way to transfer knowledge. Likewise, *research and development* activity should have increased in tropical countries. *Mobile technology* and the *Internet* have been powerful technologies for developing countries including those in the Tropics. The extent of the take-up of mobile technology is of interest. Likewise, an increase in tertiary education enrolments is a good proxy indicator to understand the development of knowledge in the Tropics. Within the tertiary sector, the number of scientific and technical journal articles also provides an indicator of research capability and output. I will look at each of these indicators in turn but the figures for each of these indicators suggest that there has been "a much greater national and international focus on technological innovation directed at the problems of tropical ecology" since the time period on which Sachs' paper was based. Perhaps his proposed policy solution has occurred, at least to some extent.

Foreign direct investment (inflows) increased substantially in all regions of the Tropics over the 30 years to 2010. Foreign direct investment to tropical nations increased more than tenfold between 1980 and 2010, from US\$11 billion to US\$157 billion. As a percentage of GDP, it has increased from 0.7% of GDP in 1980 to 2.2% in 1995 to 3.5% in 2010. This ratio was highest in the Northern Africa and Middle East (6.1%) and South East Asia (5.7%) regions. It also increased fastest in these two regions. However, the ratio declined in Central America between 1995 and 2010.

Research and development expenditure (as % of GDP) remained much lower than the Rest of the World (0.58% compared with 1.96%) in the late

1990s, but grew much faster at 18% between 2000 and 2008 compared with 9% for the Rest of the World. The fastest growing regions have been South East Asia and South America.

Mobile technology has emerged as one of the fastest growing consumer technologies ever introduced. In the Tropics mobile telephony has become the dominant means of communication and the principal gateway to increased ICT access and use, with penetration rates reaching 68% in 2010 up from 3.7% in 2000 and 0.1% in 1993 although somewhat less than the Rest of the World at 83%. The penetration is highest for South America, Central America and South East Asia all of which have higher penetrations than the Rest of the World on average.

Diffusion of the Internet in the Tropics has happened quickly in terms of both users and penetration, although access is considerably less widespread than mobile communications. Growth rates of 30% per annum between 2000 and 2010 (twice that of the Rest of the World) enabled the number of Internet users in the Tropics to reach 471 million in 2010 and achieve a penetration rate of 16.5%. All regions have grown rapidly, although Central and Southern Africa, Northern Africa and the Middle East, and South Asia lag behind the other regions.

With respect to *tertiary education enrolments per 100,000 population*, growth has been rapid from 1190 to 2031 over the 2000 to 2010 period. Although still considerably less than the ratio of 3423 students in the Rest of the World, there has been considerable catch-up. The proportional growth in Central and Southern Africa has been stronger than most other regions although the number of enrolments is still relatively low.

² The Human Development Index combines indicators of life-expectancy, educational attainment and income into a composite index. It is designed to serve as a frame of reference for both social and economic development.

³ Data for 1990 are used as the base period as data for 1995 could not be sourced. This is unlikely to have a major impact on the analysis, noting that the improvement in the performance of the tropical countries has been accelerating.

The number of scientific and technical journal articles per 100,000 population originating from authors in the Tropics has more than doubled over the 1990 to 2009 period, but this figure remains very low at 1.8 when compared with for the Rest of the World at 18.9. Consistent with research and development expenditure, the regions with the most rapid growth were South East Asia and South America.

Sachs' policy solution to develop technology in the Tropics was to have a much greater national and international focus on technological innovation directed at the problems of tropical ecology. The indicators discussed above suggest there has been considerable progress in this direction, perhaps because newer technologies are not so ecology dependent (e.g. a lower reliance on agriculture). The impressive increase in foreign direct investment implies that there has been significant technology transfer. The advent of air conditioning and additional protections from tropical diseases has also made it easier for people from temperate climates to work in the Tropics and transfer their knowledge. Furthermore, the large increase in tertiary enrolments suggests that there is growing capacity within the tropical regions to adopt new technologies. The other indicators suggest important increases in home-grown technical capability even though still considerably less than the Rest of the World. All these factors are likely to have contributed to the higher economic growth in the tropical regions.

I turn now to hypothesis (4), which relates to societal dynamics such as urbanisation and demographic transition. Have there been many changes since 1995? The indicators I will look at are as follows: *urban population, life expectancy, maternal mortality, child (under 5) mortality and youth literacy*. Although not one of the indicators in the State of Tropics Report, I will also look at *fertility* because it is an important part of the demographic transition.

Urban population (as a percentage of the total population) has increased considerably over the past 30 years, much greater than Sachs would have envisaged when writing his paper, I think.

It has been growing steadily at an annual rate of 3.3% and was 45% of the population in 2010 compared with 38% in 1995 and 30.5% in 1980. This is still less than the 56.2% for the Rest of the World. In relative terms, the biggest growth has been in South East Asia. The process of urbanisation has supported economic development by providing the labour needed for industrial activity, but has also been a factor in the expansion of slums.

With respect to life expectancy, there have been significant improvements in the tropical countries. Over the past 50 years, life expectancy has improved from 41.3 years to 65.2 years. Although this represents a considerable catch-up to the Rest of the World, it remains 7.7 years lower. Over the past 15 years, the improvement for the tropical regions has been about five years, showing some acceleration. The relatively larger increase in life expectancy in the Tropics reflects greater access to vaccines and major improvements in many of the social determinants of health, including increased access to potable water and sanitation facilities, and enhanced public health infrastructure. There are two important exceptions. Whilst deaths from most of the so-called neglected tropical diseases (NTDs) have declined, this is not the case for dengue fever. Also obesity and non-communicable diseases such as diabetes are growing concerns. The rates have been growing steadily, although they are still well below those for the Rest of the World.

Sachs noted the significant improvements in public health in a number of tropical countries (mostly Asian) that preceded their economic take-offs. These improvements in public health have also now occurred in a number of other tropical countries and might have similar impacts. Reduction of maternal and child mortality has also been an important contributor to the improvement in life expectancy. All regions experienced significant decreases in both indicators with some regions now experiencing rates lower than the average for the Rest of the World.

Fertility has decreased significantly in the tropical regions and is continuing to fall. For the 1950-55 period, the fertility rate was 6.2 which had fallen to 3.2 by 2005-10. Much of the reduction occurred prior to 1990-95 when it had already dropped to 4.1. For the South America, Central America and South East Asia regions the fertility rate is now only slightly above that for the Rest of the World. It remains high for the Northern Africa & Middle East and Southern & Central Africa regions but, in Africa at least, it is expected to fall with reductions in child mortality and improvements in the education levels of girls.

Youth literacy has improved steadily over the period from 1989-93 to 2005-10, from 79.8% of youth to 86.2%. Whilst the rate is still lower than the Rest of the World, the South East Asia, South America and Central America regions have rates higher than the Rest of the World on average. Also, the South Asia region is experiencing the most significant increase in youth literacy. This is a consequence of a significant increase in mean years of schooling over this period.

It can be seen that the societal dynamics of the tropical regions have changed in that they now represent more closely the conditions that exist in non-tropical countries. Urbanisation has definitely increased and a demographic transition is occurring because of lower mortality and fertility rates, as discussed above. The tropical countries are experiencing the so called demographic dividend to their economic growth as relatively high proportions of their populations are of working age. The improvements in youth and adult literacy mean that there is a more skilled workforce and a greater range of job opportunities for this workforce.

Societal dynamics have changed more rapidly in some regions than others with South East Asia being the most notable example. However, there are other regions such as South Asia and Central and Southern Africa where the transition has started. If Sachs' hypothesis (4) is correct, then it could be concluded that changes in societal dynamics have contributed to the faster economic growth in the tropical regions.

Sachs' hypothesis (5) is about geopolitical factors but I will not comment on this aspect of Sachs' theory because the State of the Tropics Report does not contain any relevant indicators except to note improved governance in many countries. Furthermore, Sachs' assessment is that "their role is often exaggerated when not considered alongside the underlying technological, demographic, and urbanisation processes".

Other factors

Sachs also mentions the importance of agriculture productivity to growth in the tropical regions, and notes that productivity had been much lower than the Rest of the World for a number of reasons including the lack of technology specific to the tropical ecological regions. Significant improvement appears to have been made in agriculture productivity in more recent years. Although there has been little increase in the use of land in the Tropics, output has increased dramatically because of improved productivity. Two of the important contributions have been increased irrigation and use of inorganic fertilisers both of which have their own environmental problems.

Over the past 30 years, livestock productivity has increased by 89% for cattle/buffalo (South America being the main contributor) and 44% for sheep/goats (Central and Southern Africa being the main contributor) compared with much more modest growth for the Rest of the World (3% and 4% respectively). Total cereal production has more than doubled (South America and South East Asia being the main contributors) but still lags the Rest of the World in yield even though it has improved by 67% over the past 30 years. The increase in agriculture productivity has been important because it has corresponded with an increase in demand (and prices) for agriculture commodities. Africa has generally lagged the other regions in the use of technology and improved techniques to improve agriculture productivity. However, the analysis above suggests there is some catch-up.

On the other hand, there are some warning signs with respect to future agriculture productivity. Nearly one-third of land in the Tropics suffered degradation between 1981 and 2003. This is more than the global average of 20%. South East Asia had the greatest area of land degradation at 53% but it is now much less reliant on agriculture for economic activity. Deforestation followed by poor agricultural practices were the major causes of land degradation.

Water is also an issue. The Tropics have just over half the world's renewable resources (54%). Despite this, half the tropical population was considered vulnerable to water stress in 2010 and current water use patterns are still considered unsustainable in many parts of the Tropics. Agriculture accounts for 81% of water withdrawals so is especially vulnerable.

Despite these improvements in agriculture productivity and increase in agriculture production, agriculture has become a relatively less important part of the economy in the Tropics. It was 18% of GDP in 1980, down to 15% in 1995 and further down to 12% by 2010.⁴

Sachs also referred to the ability to mobilise energy resources and suggested that tropical countries were disadvantaged because they had relatively fewer coal resources. However, electricity generation has grown much faster in the Tropics than the Rest of the World. Tropical regions accounted for 7% of electricity generation in 1980 and grew to 15% by 2010. On a per capita basis, it is still much faster with energy production increasing by 4% per annum in the Tropics over the past 30 years compared with 1.7% per annum in the Rest of the World. Furthermore, electricity generation from renewable resources (mostly hydroelectricity) has also increased much faster in the Tropics from 15% of world usage in 1980 to 23% in 2010. Imports of energy sources such as coal would have been an important contributor but the tropical regions are also richer in oil and renewable resources.

To summarise, there appears to be considerable progress in the Tropics in all the factors that

Sachs regarded as pre-conditions for improved growth, namely the "underlying technological, demographic, and urbanisation processes" as well as substantially improved agriculture productivity even though agriculture has become relatively less important as the economies have diversified. Furthermore, the "ability to mobilise energy resources" seems to have improved. Consistent with his hypotheses, these are likely to be significant factors in the greatly improved economic performance of the tropical regions. However, these may not be the only factors that matter. This issue is explored in the following section.

What other factors might be driving the improved performance of the tropical regions?

Apart from the South East Asia and South Asia regions, the tropical regions had relatively low growth compared with the Rest of the World up until the mid-1990s, i.e. the end point of Sachs' analysis. For the other regions, the improved growth started about then or shortly afterwards. Improved political stability has been one important factor that has influenced the sudden improvement in many circumstances in the Tropics. This does not hold for every tropical country and, where it does not exist, poor economic performance is one of the outcomes. Institutional strengthening and good governance are also important, which includes arrangements for collecting taxes and other revenues due to government. This applies particularly to the financial system and its supervision. Also, there needs to be a favourable policy environment that includes flexible capital and labour markets. The performance of tropical countries is mixed but generally there have been significant improvements in those countries where the economic performance is best.

One of the comparative advantages of most tropical countries is relatively low labour costs. This has facilitated a shift in manufacturing and

⁴ Agriculture includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production

certain services from developed countries to a number of tropical countries. This has been an important factor in South Asia, for example.

There are other important factors which are covered by the State of the Tropics indicators such as (i) education (mean years of schooling of adults), (ii) openness through international trade and investment (exports of goods as % of GDP, foreign direct investment, net inflows), (iii) infrastructure development (gross capital formation) and (iv) corruption.

The mean years of schooling as an adult almost doubled in the Tropics between 1980 and 2010 from 2.9 years to 5.9 years. This is still less than the Rest of the World (8.5 years). The regions with the highest mean years of schooling are the Caribbean (8.2 years) and Central America (7.8 years). It is important that these improvements continue as it has been shown that there is a strong relationship between mean years of schooling and per capita incomes.

Growth in exports of goods as a % of GDP has been very strong from 26.4% in 1980 to 37.0% in 1995 to 47.1% in 2010. This is much faster than the growth in exports in the Rest of the World, where the ratio was 25.1% in 2010. GDP growth has also been slower in the Rest of the World. Exports of goods as a % of GDP for the Tropics were actually more than 50% prior to the Global Financial Crisis. The ratio for exports (47.1%) is higher than that for imports (45.8%) so the Tropics are a net exporter, and trade in goods contributes positively to economic growth. Unfortunately there is no similar data for trade in services.

South East Asia has the highest proportion of exports to goods as a % of GDP (90.2%) but this large number may be due in part to re-exports from places like Hong Kong and Singapore. South Asia has the strongest growth in exports driven by the trade liberalisation policies of India and Bangladesh. These regions in particular have more mixed economies and have significant exports from industries other than agriculture. Services are also becoming increasingly important.

Foreign direct investment, net inflows increased substantially in all regions of the Tropics in the 30 years to 2010 assisted in part by liberalisation policies in many countries. Foreign direct investment to tropical nations increased more than tenfold between 1980 and 2010, from US\$11 billion to US\$157 billion. As a percentage of GDP, it has increased from 0.7% of GDP in 1980 to 3.5% in 2010. The petroleum industry was an important contributor. When consideration is given to this increase in foreign investment together with the story on exports, tropical countries have clearly become more open. Developed countries have traditionally been the source of funds for foreign investment but in recent years, developing countries such as China have also become important investors.

With respect to gross capital formation, there has been sound performance in the Tropics which has contributed to both current and future economic growth. This indicator includes both private and public outlays. As a proportion of GDP, gross capital formation has been growing at about 0.5% per annum over the last 30 years and the ratio is now 25%. In the Rest of the World, the ratio has declined at a rate of 0.1% per annum to 22%, and is now lower than for the Tropics. The ratio is highest in South Asia (35%) and South East Asia (30%) with the highest growth in South Asia where there have been active policies in place in India to encourage investment. The growth in South East Asia was affected somewhat by the Asian Financial Crisis in 1997 but has since recovered.

Corruption, according to the World Bank's World Governance Indicators (World Bank 2013), is more prevalent in the Tropics than in the Rest of the World, and the gap has not changed significantly since 2000. Corruption tends to be more prevalent in resource rich developing countries, especially where there is weak rule of law and state ownership of resources.

It is difficult to assess the influence of corruption on economic growth. Studies have shown that it will have a negative impact and the World Bank is trying to address it for that reason. Certainly

the most corrupt countries are among those that performed the worst economically. It would be interesting to look at whether there is correlation between those countries that have reduced corruption (unfortunately this number is small) and economic growth.

To summarise, apart from the pre-conditions implied by Sachs' hypotheses and the other factors mentioned in the opening paragraphs of this section, it appears that there is a relationship between economic growth and education, openness through international trade and investment, and infrastructure development. It could be argued that Sachs' pre-conditions are necessary but not sufficient, as other factors are also important.

What has been the industry breakdown of economic growth?

It is illuminating to look at how various sectors of the economy contribute to growth. As shown in Table E4.4, the trend for the Tropics has been the decline in the relative importance of agriculture⁴ (even though it has increased substantially in actual size), and the increased importance of both industry⁵ and services⁶. Industry has increased from 29% of GDP to 32% between 1995 and 2010. The increase for services is slightly greater from 49% of GDP to 53%. This is not unexpected. As countries develop, there is generally relatively less reliance on agriculture.

The ability to adapt the industry structure of economies is important. To quote Sachs, 'these (more successful) economies were able to establish new productive sectors (e.g. textiles, electronic machinery, semiconductors and electronic components) where tropical production was not burdened by climatic or ecological factors' (Sachs 2000 pg. 31).

The story is quite mixed across the regions as is the relative importance each sector. For agriculture the biggest decreases between 1995 and 2010 were in Southern and Central Africa, Northern Africa and the Middle East and South Asia. For South East

Asia, the decrease in the relative importance of agriculture occurred earlier.

The relative increase in the importance of industry started from the mid-1990s. For this grouping, the biggest increases have been in Southern and Central Africa, and Northern Africa and the Middle East. There were actually decreases in the relative importance of industry in the Caribbean and Central America.

On the other hand, for services, the Caribbean and Central America were among the regions with the biggest increases along with South East Asia from 1995 to 2010. The trend towards services started even earlier in South East Asia. There was a significant fall in the relative importance of services over this period in Northern Africa and the Middle East.

Differences between regions

In this section I rely mostly on information in the State of the Tropics Report. The approach I have taken is to arrange the regions by their annualised growth over the 1995 – 2010 period and then look at where the regions are relatively strong or weak, mostly in terms of the indicators in the Report (see Table E4.5). The economic performance of the regions is quite mixed and will use Table E4.5 to see whether there are any patterns that help explain this mixed performance.

It is worth noting the following pen pictures of the nature of the growth for each of the regions.

- South Asia: Very strong growth well before 1995, accelerating through the 2000s

- South East Asia: Very strong growth started well before 1995 and has continued with a slight setback during the 1997 Asian Financial Crisis
- Central and Southern Africa: Very strong growth only started during the 2000s but has been accelerating
- Caribbean: Strong but steady growth since 1995

⁵ Industry includes mining, manufacturing, construction, electricity, water, and gas.

⁶ Services include wholesale and retail trade (including hotels and restaurants), transport, and government, financial, professional, and personal services such as education, health care, and real estate services.

Table E4.4 Contribution of different sectors to GDP (%)

	1980			1995			2010		
	Agriculture	Industry	Services	Agriculture	Industry	Services	Agriculture	Industry	Services
Tropics	18%	29%	48%	15%	29%	49%	12%	32%	53%
Central & Southern Africa	32%	27%	42%	30%	27%	44%	24%	34%	43%
Northern Africa & Middle East	26%	25%	42%	32%	22%	36%	20%	37%	32%
South Asia	35%	21%	48%	26%	25%	49%	19%	28%	53%
South East Asia	24%	30%	43%	16%	32%	48%	12%	34%	54%
Caribbean	13%	23%	55%	8%	25%	60%	5%	18%	71%
Central America	9%	25%	53%	6%	30%	50%	4%	26%	62%
South America	11%	35%	48%	8%	32%	51%	6%	36%	53%
Oceania	10%	36%	53%	7%	29%	64%	6%	29%	64%
Rest of the World	6%	38%	50%	5%	32%	55%	4%	30%	63%
World (estimated)	8%	36%	50%	7%	31%	54%	6%	31%	61%

Source: World Bank (2013), State of the Tropics project.

- Northern Africa and the Middle East: Growth has been steady since 1995 but there has been significant population increases so per capita growth has been quite small
- South America: Strong growth only really started in the 2000s after many decades of weak growth
- Central America: Apart from the late 1990s relatively low growth during this period, with per capita GDP hardly growing at all
- Oceania: Relatively weak growth that has been declining in magnitude with virtually no growth in per capita GDP

It is difficult to see a clear pattern from Table E4.5. Exports are clearly important for the stronger growing regions but the nature of the exports vary quite a bit from one region to another. South Asia seems to be taking advantage of relatively low labour costs but with improvements in education and youth literacy. Their economy has had significant increase in both industry and services. This increase has been supported by capital formation although foreign investment remains surprisingly low.

The strong performance of South East Asia is not surprising. There has been an excellent performance on the full range of economic, scientific and social indicators. Exports have clearly been a big part of the story. In the past there would have been a comparative advantage through relatively low labour costs, however their costs would no longer be low compared with South Asia for example. They have needed to add value through improved labour productivity or a switch to less labour intensive industry. The indicators suggest this may be happening. Also, services are playing a much larger role in the economy than previously.

Although Southern & Central Africa remains low on a range of science, education and other social indicators, there has been an increase in foreign investment. This may be due to foreign investors taking advantage of low labour costs,

even though most industry in the region is based around commodities such as oil. Also, there have been important improvements in agriculture productivity. Export performance has grown steadily as a percentage of GDP but nowhere near as strongly as South Asia which also has relatively low labour costs. The Southern & Central Africa region is large and diverse: culturally, historically and politically. It is therefore not surprising that there is a great deal of variation in the performance of nations within the region.

The Caribbean has high and improving education indicators, especially tertiary education. The labour costs for the region are relatively high. There has been a big switch from industry to services possibly as a consequence. Also, exports (and economic growth) have been limited because Cuba does not have as much access to open markets and investment as many other countries.

Oceania is the worst performing region especially when you look at growth in per capita GDP. Their tertiary education levels are high, mostly because of the contribution of tropical Australia and Hawaii, but other education levels are declining. The labour costs of the region are relatively high compared with the high performing regions so the comparative advantage of the smaller countries is not clear.

The influence of China and India is important both because of their own contribution to economic growth and the contagion effect on other economies in the region. Only parts of both countries are in the Tropics so this diminishes their impact, especially China. In India, we have estimated 57% of the population live in the Tropics and contribute to 68% of India's GDP. In China, only 12% of the population live in tropical regions producing 12% of national GDP. However, even after removing the direct contributions of China and India, the regions still show strong growth, although at a lower level. China and India, although important, are only part of the story.

The Future

The World Bank's Global Economic Prospect (World Bank 2014) provides a positive picture for economic growth for the Tropics driven primarily by strong global demand for their commodities and services. However, the predicted performance is mixed across the regions as it is at present.

South Asia is seen as growing strongly and getting back to near previous levels of very high growth. South East Asia is seen as growing at high but slowly reducing levels. Central and Southern Africa is shown as having increasingly high economic growth at relatively high levels. The Caribbean is shown as having steady growth at reasonably high levels. Northern Africa and the Middle East is shown as having improving but relatively weak growth. Both South America and Central America are shown as having steadily improving economic growth prospects although growth will not be as high as most other regions. For Oceania, growth is shown as steady at relatively low levels but could do better depending on the performance of Papua New Guinea.

There will be a range of challenges if the Tropics are to continue their current and projected strong performance. One such challenge is climate change and the climate change essay suggests that global warming will be an ongoing issue for the Tropics despite acknowledged uncertainty about other climate outcomes. Although it is unclear how rising temperatures and changing weather conditions will affect highly variable weather patterns such as rainfall and tropical cyclones, small changes in a region with reasonably constant temperatures are likely to have a larger impact than in areas with a more variable temperature range.

Tropical countries will need to invest in infrastructure development through private and public capital formation, expenditure on research and development relevant to the needs of the Tropics, improved access to the Internet and other relevant technologies, and continue to strengthen institutions and governance to reduce corruption and similar constraints on business activity.

Table E4.5 Analysis of the relative strengths and weaknesses of regions

	Relative Strengths	Relative Weaknesses
South Asia (7.0%)	<ul style="list-style-type: none"> Large increase in exports Low labour costs Large increase in capital formation Switch from Agriculture to Industry & Services Increases in life expectancy and youth literacy 	<ul style="list-style-type: none"> Low level of Internet usage Low level and relatively small increase in foreign investment
South East Asia (5.3%)	<ul style="list-style-type: none"> High level and growth in foreign investment Increase in R&D and technology indicators High level and growth in capital formation Increase in a range of social indicators Increased urbanization High level of exports Switch to Services 	<ul style="list-style-type: none"> High (and increasing) income inequality
Central & Southern Africa (5.3%)	<ul style="list-style-type: none"> Increase in foreign investment Switch from Agriculture to Industry Low labour costs Improvement in Agriculture productivity 	<ul style="list-style-type: none"> Technology still at low level Tertiary education at low level but growing quickly Fertility is high
Caribbean (4.4%)	<ul style="list-style-type: none"> High level and growth in tertiary education High level for mean years of schooling Switch from Industry to Services 	<ul style="list-style-type: none"> Net importer of goods
Northern Africa & Middle East (3.7%)	<ul style="list-style-type: none"> Large increase in foreign investment Switch from Agriculture to Industry Significant net exporter 	<ul style="list-style-type: none"> Technology indicators are relatively low Fertility is high Decline in exports as % of GDP
South America (3.1%)	<ul style="list-style-type: none"> Increase in a range of technology indicators Increase in youth literacy Large increase in agriculture productivity Relatively high commodity prices 	<ul style="list-style-type: none"> High income inequality
Central America (3.1%)	<ul style="list-style-type: none"> Increase in a range of technology indicators Increase in youth literacy Increase in mean years of schooling Switch from industry to services 	<ul style="list-style-type: none"> Decline in foreign investment as % of GDP
Oceania (3.1%)	<ul style="list-style-type: none"> High level of tertiary education 	<ul style="list-style-type: none"> Poor performance on a range of economic indicators Imports growing faster than exports

Source: State of the Tropics project

References

Conclusions

My conclusion is the pre-conditions for growth as outlined by Sachs paper are necessary, but not sufficient to guarantee that the Tropics will match or exceed growth in the Rest of the World. One of the most important conditions is having appropriate institutional and policy settings. This is seen not so much by the information in this report but the very different performance of countries within a region.

Returning to the Sachs pre-conditions, significant factors have been the improvement in agriculture productivity coupled with improvements in health and public stability. These have increased the workforce available for productive activities and enabled tropical countries to take advantage of available technologies.

Once these essential conditions have been met, economic growth will be improved further through education, openness to trade and investment, and infrastructure development, among other things. GDP depends on the factors of production (e.g. labour and capital) and how you use these factors (e.g. technology). As the essay shows, there have been improvements in all these areas in the tropical regions. In particular, trade and investment have facilitated the transfer of technology and knowledge and enabled countries to focus on activities where they have a comparative advantage. Furthermore, the transfer of technology and knowledge has reduced the need for countries to undertake these types of innovative activities themselves.

Is tropical underdevelopment a thing of the past? Clearly the answer is no. However, unprecedented growth and change in recent years has closed the gap between the Tropics and the Rest of the World, and within an appropriate policy framework can continue to do so into the future.

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Stock exchange, Ghana.
Image: Jonathan Ernst, World Bank.



Jakarta.
Image: Jerry Kurniawan.



Chapter 8
Governance





Chapter 8.1

Governance | Human security, crime and corruption

Dadaab refugee camp, Kenya.
Image: B Bannon UNHCR.

Summary of human security, crime and corruption indicators

Indicator	Tropics	Central & Southern Africa	Northern Africa & Middle East	South Asia	South East Asia	Caribbean	Central America	South America	Oceania	Rest of the World	World
Refugees 1990 – 2010 ('000)	6,790 - 4,258	4,427 - 1,317	209-155	207-155	695-822	16-36	131 - 19	8 - 411	0 - 2	7,999 - 6,107	14,790 - 10,365
Homicide rate per 100 000 population, 2004	15	22	11	5	9	15	17	33	9	6	9
Corruption (World Governance Indicators - 2011)	Control of Corruption*	-0.35	-0.58	-0.89	-0.65	-0.13	0.45	-0.33	-0.48	0.05	0.30
	Rule of Law*	-0.41	-0.70	-1.01	-0.32	-0.11	0.20	-0.50	-0.65	0.26	0.33
	Regulatory Quality*	-0.39	-0.63	-0.98	-0.41	0.17	0.12	0.07	-0.44	-0.42	0.38

*The World Governance Indicators are calculated using data reporting the perceptions of governance from a wide variety of sources, and organising them into clusters corresponding to six dimensions of governance, namely Voice and Accountability, Political Stability & Absence of Violence/Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law and Control of Corruption. WGI values range from -2.5 to 2.5, with higher values representing better performance (see Box 8.1.4).

Conflict, corruption and violence have a direct and often traumatic impact on the wellbeing of individuals, families and communities. The security of individuals is an important determinate for national, regional and global stability and progress.

Human insecurity can be the result of factors at multiple levels. National and regional level factors such as persecution, genocide, human right's abuses, civil war, and invasion can result in widespread insecurity. Additionally, high levels of crime at a community level can lead to people feeling unsafe and unsecure. Corrupt governments, organisations and individuals can affect development at its very core by skewing decision making, budgets and policy implementation.

People displaced by insecurity (refugees) are particularly isolated from society, often emotionally traumatised, unable to work and

face language barriers. Similarly, serious crime and corruption can affect a person's ability to find stable employment and move around with freedom. Corruption by those in power denies the participation of people in society by diverting public funding into private hands and denying state support, usually to those who need it the most. Additionally, a nation with weak governance and 'rule of law' may find it difficult to attract legitimate investors.

Crime and corruption have long been obstacles for nations trying to bring about the political, economic and social changes desired for development.

Indicators:

Refugees – the number of residents fleeing a country for reasons of fear or persecution is an indicator of the standard of governance and level of violence (or risk of violence) in society.

Homicide rate – the homicide rate provides an indication of the prevalence of crime in a society. While representing only a small fraction of overall crime, homicide is an offence which has a relatively consistent definition, and is also a crime that tends to be reported.

Corruption – corruption affects all levels of society, but tends to have the greatest impacts on the poor. It increases the cost and lowers the quality of public services, and can restrict access to water, education, health care and other key services. It also distorts people's relationships with and trust for public officials, the police and people in authority.

Is it getting better?

Refugees – Globally the number of refugees has fallen 30% over the past two decades, from 14.8 million in 1990 to 10.4 million in 2010. Refugee numbers in the Tropics declined significantly between 1994 and 1997, but numbers have stabilised at around 4 million over the past decade. The decline in refugee numbers between 1990 and 1999 was driven by the repatriation of significant numbers of refugees to Mozambique and Ethiopia in the Tropics, and Afghanistan in the Rest of the World, as conditions in these nations improved after extended periods of unrest. The proportion of the population who are refugees is similar in the Tropics and the Rest of the World (0.15%). Although not reflected in the latest data, refugee numbers in the Middle East have increased rapidly in recent years.

Homicide rate – Although time series data are not available, in 2004 the homicide rate in the Tropics was much higher than the Rest of the World. The Tropics reported

a homicide rate of 14.5 per 100,000 population or around 375,000 murders. This was considerably higher than the homicide rate of 5.6 per 100,000 in the Rest of the World. South America, Central & Southern Africa, and Central America reported the highest homicide rates, at 32.9, 21.6 and 17.0 per 100,000 population respectively. South America's rate is more than treble the global rate.

Corruption - In 2011 the Tropics achieved lower scores than the Rest of the World for the assessed governance indicators, indicating higher rates of corruption. For 'Control of Corruption', 74% of nations in the Tropics had a rating of less than zero, compared to 45% in the Rest of the World. For 'Rule of Law', 75% of nations in the Tropics had a rating of less than zero, compared to 41% in the Rest of the World. Although the Tropics performs marginally better with respect to the 'Regulatory Quality' indicator, the story is similar.



Darfur. Image: Albert Gonzalez, UNAMID.

Refugees

The concept of human security is broader than safety, and also takes into consideration humanitarian, economic and social issues such as human rights, governance and access to economic opportunity, education and health care (UNDP 1994). The number of displaced persons is an indicator of human security, which includes internally displaced persons (IDPs), asylum seekers and refugees¹.

Displaced persons have abandoned their homes because of threats to their life and liberty – often as a result of religious persecution, cultural discrimination, ethnicity, political belief, human rights abuse or armed conflict and violence – and the number of refugees is an indicator of international human security (that is, people who do not feel safe in their own country) (UNHCR 2006). Nonetheless, in any given year, internally displaced persons typically outnumber refugees.

Trends

Globally the number of refugees has fallen 30% over the past two decades, from 14.8 million in 1990 to 10.4 million in 2010², though there was an increase in 2000 and a spike in refugee numbers in 2006 and 2007 which has since stabilised at around 2 million additional refugees compared to 2005 (see Table 8.1.1).

The decline in numbers between 1990 and 1999 was driven by the repatriation of refugees to Mozambique and Ethiopia in the Tropics, and to Afghanistan in the Rest of the World, as conditions in these nations improved after extended periods of unrest. Renewed conflict in Afghanistan was the major contributor to the increase in refugee numbers in 2000, and the spike in 2006 was largely due to civil war in Iraq which saw the outflow of 1.2 million people. The further deterioration in conditions in Afghanistan (Dani 2013) has accounted for the balance of the increase in refugee numbers from 2006.

Refugee numbers in the Tropics declined significantly between 1994 and 1997, but have

since stabilised at around 4 million over the past decade. Globally, changes in the total number of refugees since 1998 have been driven by factors in the Rest of the World, most notably in Iraq and Afghanistan.

The decline in refugee numbers globally reflects a reduction in the number of armed conflicts and civil wars since the 1990s and the end of many longstanding disputes within troubled nations (UNHCR 2006). As a result, human rights conditions have improved in many nations and this has enabled several large scale refugee repatriations.

The data in this report do not include the large numbers of refugees fleeing recent conflicts in the Middle East, particularly Syria. The UNHCR estimates more than 2 million people were living in refugee camps in September 2013 as a result of this conflict (UNHCR 2013).

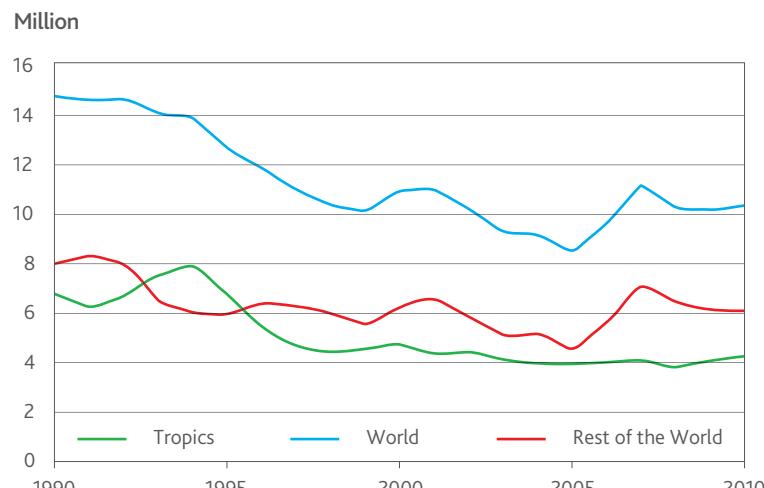
In the Tropics, Central & Southern Africa, South Asia and Central America report a decrease in

refugee numbers since 1990 (see Table 8.1.1). The most significant improvement has been in Central & Southern Africa where refugee numbers fell by 3.1 million (70%) to 1.3 million in the two decades to 2010. Several nations in Central & Southern Africa were affected by long running civil wars which weakened civil institutions and the rule of law and, subsequently, the confidence of citizens to be treated fairly

¹Displaced persons include internally displaced persons, asylum seekers and refugees. Internally displaced persons are people who leave their homes owing to a well-founded fear but have not crossed a border to another nation. An asylum seeker is a person who has crossed a national border seeking protection as a refugee, but who is awaiting an assessment of the validity of their claim. A refugee is an asylum seeker who has had their claim assessed and confirmed. The definition of a refugee is narrower than that of an IDP owing to the exclusion of generalised violence, and natural/human made disasters as accepted reasons for displacement. The rights of refugees to participate in economic and social activities in host nations varies from nation to nation.

²This excludes Palestinian refugees, which come under the jurisdiction of United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA) as opposed to the United Nations High Commissioner for Refugees (UNHCR). The number of Palestinian refugees is estimated at 4.8 million in 2010, up from 2.4 million in 1990.

Figure 8.1.1 Refugee population by place of origin



Source: World Bank (2012), UNHCR (2012), State of the Tropics project.

and justly. There have been large refugee flows in nine of the region's 37 nations which have accounted for the vast majority of regional refugee movements. However, in most instances there have subsequently been significant repatriations, notably between 1990 and 1998 as security improved. Central & Southern Africa accounted for 31% of refugees from the Tropics' in 2010 compared to 65% in 1990. The major improvements have been in Ethiopia, Liberia and Mozambique (see Box 8.1.1).

South America, Northern Africa & Middle East and South East Asia have had the largest increase in refugee numbers in the 20 years to 2010, up by 400,000, 190,000 and 125,000 respectively. In South America refugee numbers increased 50 fold to 411,000 in 2010, with the vast majority coming from Colombia due to instability associated with conflict between the government and guerrilla forces and violence associated with

narcotics and trafficking (UNHCR 2011). In 2009, and for the first time, Northern African & Middle East reported the highest number of refugees of the tropical regions. In 2010 Northern Africa & Middle East accounted for 35% of refugees from the Tropics, up from 19% in 1990, driven by increased refugee numbers from Somalia.

Refugees and host nations

Refugees impose a variety of economic, environmental, social and security burdens on host nations, but can also deliver benefits in the form of humanitarian assistance, economic assets and human capital. The dynamic will vary across nations, and will depend on a range of factors such as the political and economic position of the host nation and the nature of host-refugee relations (World Bank 2011a).

For host nations, a large number of refugees can place strain on food and water supplies as well as social and economic infrastructure such as housing, medical and education services and labour markets (UNHCR 1997). Security threats can include bilateral tensions with the source refugee nation and animosities between refugees and the local community (World Bank 2011a). Such threats can have a destabilising effect on host nations. A better understanding of the environmental impacts of large refugee camps is also emerging, including their longer term effects of land degradation, deforestation and water pollution (UNHCR 2002).

The majority of refugees are hosted in nations sharing land or maritime borders with the nation of origin. As the vast majority of refugees are from developing nations and regions, it follows that the majority of refugees are hosted in nations that are also developing. Developing nations provide

Table 8.1.1 Refugee numbers by place of origin

	1990	2000	2005	2010	% change 1990 to 2010	PPT* contribution to change
Tropics	6,790,824	4,740,469	3,953,157	4,257,610	-37	-37
Central & Southern Africa	4,427,169	2,325,546	1,772,978	1,317,243	-70	-46
Northern Africa & Middle East	1,305,040	1,447,583	1,325,039	1,495,016	15	3
South Asia	208,574	132,861	120,139	154,929	-26	-1
South East Asia	695,035	752,515	618,521	821,677	18	2
Caribbean	15,616	27,823	33,621	36,328	133	0
Central America	131,272	35,589	11,686	19,166	-85	-2
South America	8,118	18,101	69,701	411,179	4,965	6
Oceania	1	451	1,473	2,071	206,124	0
Rest of the World	7,998,719	6,233,408	4,509,177	6,107,006	-24	-28
World	14,789,543	10,973,877	8,462,334	10,364,616	-30	-65

Source: World Bank (2012), UNHCR (2012), State of the Tropics project.

*Percentage point.

Box 8.1.1 Mozambique

The return of 1.45 million people to Mozambique in the 1990s is one of the most successful refugee repatriation stories in recent times. For 15 years Mozambique was wracked by civil war, its people were subject to torture and execution, and a large proportion of civil and economic infrastructure was destroyed. More than one third of Mozambique's population of 17 million was displaced, around 4 million internally and 2 million as refugees in neighbouring nations (Wilkinson 1998).

When the 1992 peace agreement was finalised Mozambique was considered a broken nation, and there were few incentives for displaced people to return home (Wilkinson 1998). A year after the hostilities ended there were still around 1.2 million refugees, but by 1996 there were only 34,000.

In addition to UNHCR initiatives to assist with the provision of food, shelter and equipment and to rebuild

infrastructure, the successful repatriation was assisted by the fact that many family groups had remained together or reunited quickly after the conflict, there were few orphaned children, property disputes were uncommon as land was plentiful and political and military differences were resolved quickly. Favourable weather conditions also provided good harvests. These factors acted to speed up the political reconciliation and reintegration processes.

The situation in Mozambique is considered unusual, and there are many examples of refugees remaining in asylum camps and refusing to return to their homeland after civil conflicts have ended.

In 2010, refugee numbers from Mozambique are low (130), and although it is a poor nation, it is now a place of asylum for refugees, primarily from other African nations.

asylum for around 80% of the world's refugees (UNHCR 2010). Of the 48 least developed nations in the world, 35 are refugee hosts, and 31 of these nations are in the Tropics (nine in Northern Africa & Middle East, 20 in Central & Southern Africa and one in each of the South Asia and South East Asia regions) (UNHCR 2010).

The refugee burden in the Tropics is significant. In 1990, tropical nations hosted 47% of the world's refugees, falling to 37% in 2010.

Host nations carry a significant burden in the initial stages of a refugee influx. Nonetheless, where permitted, refugee populations have shown that they can contribute to economic activity in host nations. For example, refugees have been able to supply labour to expand output from labour intensive industries such as agriculture, and to stimulate local economies by increasing demand for goods and services. The allocation of financial aid to develop infrastructure in host nations also provides flow-on benefits to local communities (World Bank, 2011a).

Protracted refugee situations

Although the number of refugees has been trending down over the past two decades, each year there can be significant changes in the number of people that are either becoming refugees or being repatriated. This ebb and flow is influenced by factors in the refugee home nation, and the reality is that any refugee situation can range in duration from being short term to very protracted.

Refugee numbers can decrease as a result of repatriation, resettlement or integration into the host nation. Only a small number of nations offer resettlement programs. Resettlement numbers were down to 99,000 in 2010 (compared with 112,000 in 2009) and there were 197,600 repatriations, the lowest number in 20 years. While data on local integration are limited, it appears to have been less effective in recent years in reducing refugee numbers (UNHCR 2010).



Red Cross Workers, Mozambique. Image: EU Humanitarian Aid and Civil Protection.

Protracted refugee situations³ are therefore an ongoing challenge for the international community, with 69% of the 10.4 million refugees in 2010 classified as being in protracted situations, and with many having limited prospects for durable solutions.

Protracted situations stem from a combination of factors, including ongoing risk conditions in home nations, policy responses and conditions in host nations, and a lack of engagement by the international community. Ongoing conflict, fear of persecution and a lack of basic infrastructure in home nations are common reasons for refugees not returning home. At the same time, host nations have to manage the often long term nature of the refugee situation, responding by closing borders to new arrivals, confining refugees to overcrowded camps or restricting the movement and rights of refugees (UNHCR 2002). This can have significant implications for refugees, and impact access to a safe environment as well as opportunities for employment, education, health services and other basic necessities.

Latest data (for 2004) report that 61% of the refugees from tropical nations were in a protracted situation. The majority of the affected refugees were from Central & Southern Africa (1.2 million) and Northern Africa & Middle East regions (786,000). Since 2004 there has been a sharp decline in the number of refugees from three of the four Central & Southern Africa nations that reported a significant number of protracted refugees, suggesting the number of protracted refugees has also fallen. The situation in Northern Africa & Middle East is less encouraging with refugee numbers almost doubling in two out of four protracted refugee nations, and static in a third.

The Rest of the World has not been immune to the protracted refugee situation. Afghanistan has been the leading source of refugees since 1990, though numbers declined from 6.3 million to 3.1 million in 2010. Pakistan and Iran host 96% of refugees from Afghanistan (UNHCR 2010). Around 80% of refugees from Afghanistan were living in a protracted situation in 2004.

Historically, protracted refugee crises have been resolved through the combined efforts of humanitarian organisations and political and security stakeholders. This integrated approach has been missing from more recent protracted refugee situations. The problem has been compounded by international donors influencing the direction of their financial aid to short-term, high profile refugee situations, and by 'donor fatigue'.

Looking forward

The unique circumstances of each displaced person and refugee situation can mean that finding sustainable solutions is not easy. Especially for refugees, there is a need for improved international cooperation and an international commitment to ensure their safety and rights in both home and host nations. An increase in the number of protracted refugees suggests that durable solutions in home nations are becoming harder to achieve, putting greater pressure on host nations and the international community to find solutions that don't involve repatriation.

Looking forward, climate (or environmental) refugee numbers are likely to increase as extreme weather events become more common and displace large numbers of people. At the same time, more gradual impacts of climate change such as rising sea levels have the potential to fundamentally change international relationships as part, or whole, nations are lost, and large populations need to be relocated (see Box 8.1.2).

³In 2004 the UNHCR identified a protracted refugee situation as one where 25,000 or more refugees of the same nationality have been in exile for more than five years in a given host nation.

Box 8.1.2 Climate refugees

Climate refugees are people who have had to move due to sudden or gradual changes to their natural environment caused by climate change. Climate change has been linked to a host of negative environmental impacts including rising sea levels and increased occurrences of flooding, drought and water scarcity and extreme weather conditions such as cyclones. These events can lead to short or long term displacement of individuals either within or across national borders, and increase international security issues and risks.

The most vulnerable nations to rising sea levels in the Tropics are Kiribati, Vanuatu, the Marshall Islands, the Maldives, Tuvalu and Bangladesh. In the most extreme climate change scenarios it is likely that a number of nations will disappear as a result of climate change, leaving their inhabitants stateless. While island nations such as Kiribati and Tuvalu have small populations (at 98,000 and 10,000 respectively in 2010) relocating these populations in a way where culture is maintained and people are able to continue living lives they value is a challenge for the future.

In Bangladesh around 500,000 people have been displaced with the permanent submersion of parts of Bhola Island since 2005. Rising sea levels coupled with intensifying storm surges put a significant proportion of Bangladesh's population at risk of future displacement, with major consequences for economic and social dynamics in Bangladesh and neighbouring nations as people look for more secure areas to live.

Despite millions of people being at risk of becoming climate refugees there is a lack of government and international agency recognition of their specific circumstances as they don't satisfy the traditional refugee criteria. As such, there are currently no international laws to protect the rights of climate refugees – a situation that warrants attention by the international community.



Kiribati. Image: Johanna Mustelin.

Homicide rate

The intensity and organisation of violent crime can take many forms, and can have a major impact on the wellbeing of victims and communities. Victims of crime may suffer financially, physically, psychologically and emotionally, and the fear of crime can affect a population's sense of security and willingness to engage in civil society. Violent activities of organised criminal groups can also have broad political consequences. Crime also incurs direct financial costs on communities for the provision of law enforcement services by the police, as well as court, legal and correctional services (ABS 2004).

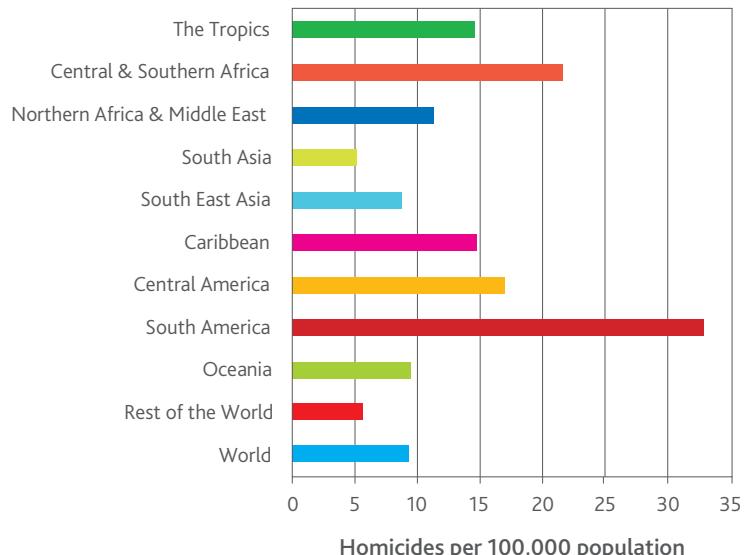
While representing only a small fraction of overall crime, intentional homicide⁴ is one of the most serious offences in civil society. Killing is treated seriously in all societies, and homicide tends to be recorded more effectively and in a more consistent manner than other crimes.

The relationship between higher rates of violence and homicide and fragile institutional capacities is widely accepted, and nations with higher respect for the rule of law and effective criminal justice systems tend to have lower homicide rates. There is also a strong association between insecurity engendered by the risk of violence and underdevelopment (Geneva Declaration on Armed Violence and Development 2011). Without security, human, social, and economic development suffers.

A range of social factors are associated with high rates of violence and homicide. For example, most violent crime is committed by and against males aged between 15 and 30. High youth unemployment, limited educational opportunities, weak judicial systems and easy access to weapons all influence homicide rates. Robbery-related homicide rates also tend to be higher in nations with greater income disparities (ECOSOC 2012).

Violent crime and homicide also have significant economic costs. High homicide rates are a sign of social instability; can influence decision making by both domestic and foreign investors; increase security and other costs of doing business; discourage the accumulation of assets; and deplete

Figure 8.1.2 Homicide rate



Source: World Bank (2012) - International Public Health Sources, State of the Tropics project.

the skilled labour force – primarily through the flow of human capital to safer nations. These factors erode business confidence and constrain a nation's longer term growth prospects.

Trends

A number of homicide datasets are available, though each is characterised by a short time series, and with data missing for many nations and years. These issues make trend analysis difficult. For 2004, international public health data are used for analysis here, primarily because it has almost complete coverage of nations. The United Nations Office on Drugs and Crime (UNODC) also reports a time series dataset but it has limited national coverage, particularly for African and Oceania nations. Nonetheless, this dataset is useful for trend analysis of the regions for which it has a good coverage of nations.

In 2004 the Tropics reported a homicide rate of 15 per 100,000 population (see Figure 8.1.2), or around 375,000 murders. This was considerably higher than the homicide rate of 6 per 100,000 in the Rest of the World. In the Tropics, South America, Central & Southern Africa and Central America reported the highest homicide rates at 33, 22 and 17 per 100,000 population respectively. South America's rate is more than treble the global rate.

Looking at 2004 data, homicide rates in South Asia, South East Asia and Oceania are the lowest of the tropical regions, with each reporting less than 10 homicides per 100,000 population. South Asia had the lowest homicide rate at 5.1 per 100,000.

⁴ Intentional homicide is the unlawful death purposefully inflicted on a person by another person, and captures a wide range of acts from domestic disputes that result in killing; interpersonal violence; violent conflicts over land, or resources; inter-gang clashes; and predatory violence and killing by armed groups.

population, making it the only tropical region with a homicide rate comparable to the Rest of the World. In 2004 South America and Central & Southern Africa reported homicide rates around seven and five times higher respectively than in South Asia.

The wide range of results across regions suggests that homicide rates are sensitive to local factors. This is hardly surprising given each nation's unique cultural, historical, political, economic, and social context. Some regions show common patterns across nations while others exhibit a wide disparity. Even within nations homicide rates can vary markedly.

Looking at time series data, homicide rates are consistently high in the three tropical regions for which data are available (see Figure 8.1.3). While rates in South America have been static, they have been trending up in the Caribbean and Central America in the decade to 2010 (see Box 8.1.3). The significant presence of organised crime groups and high levels of income inequality in these regions contribute to high homicide rates. Guatemala, Honduras and Panama all had Gini co-efficients⁵ greater than 60 in 2010, indicating high income inequality (World Bank 2012).

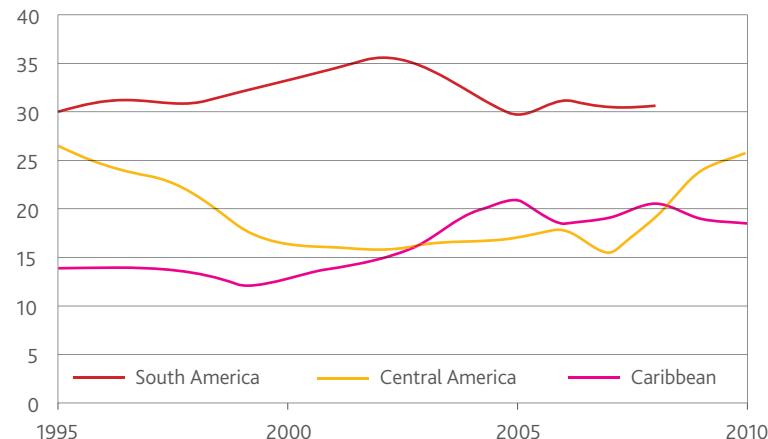
For other tropical regions there are insufficient data for trend analysis, but for many of those nations for which some data are available homicide rates have tended to fall. Also, and notably in many non-tropical regions, significant advances in medical technology and services have led to a decrease in the lethality of assaults and contributed to lower homicide rates.

Economic and social factors

Income inequality is recognised as a factor influencing homicide rates (UNODC 2011). In the Tropics, Central & Southern Africa, the Caribbean, Central America and South America each report a high degree of income inequality, with straight average Gini coefficients ranging from 44 to 52 in the 2005–2009 period compared to 38 for the Rest of the World. In fact, using latest available

Figure 8.1.3 Homicide rates – Caribbean, Central America and South America

Homicides per 100,000 population



Source: World Bank (2012) - Criminal Justice & International Public Health Sources, State of the Tropics project

Note: Due to insufficient time series data the Caribbean does not include Antigua & Barbuda, Barbados, Haiti and Saint Lucia; Central America does not include Belize or Honduras; and South America does not include Bolivia or Suriname.

data for the period 2005 to 2009, nine of the ten nations in the world reporting the highest Gini coefficients are in these four tropical regions.

High levels of income equality in these regions are often exacerbated by ethnic class divisions, as well as exclusionary factors such as unequal access to employment, education, health and basic infrastructure. These issues can limit opportunities for those at the bottom of the social and economic scale to earn a living through non-violent means (UN-HABITAT 2007).

In a similar vein, there is a strong inverse relationship between homicide rates and human and economic development. This is fairly striking when GDP per capita and homicide rates are compared. In 2004 GDP per capita in the Rest of the World was around three times higher than in the Tropics, and it had a homicide rate around one-third that of the Tropics. Central & Southern Africa reported the lowest GDP per capita of the tropical regions in 2004 and, with a Gini coefficient of 45, a high degree of income inequality. Perhaps

not surprisingly, at 22.8 homicides per 100,000 population, Central & Southern Africa reported the second highest homicide rate of the tropical regions.

The United Nations Human Development Index (HDI) takes a broader view of wellbeing than income and, in addition to GDP per capita, includes measures of life expectancy, literacy and education in its calculation. Using this measure, the link between human development and homicide rates is also evident. In 2004 and 2005 the 22 nations with the lowest HDI scores reported a population-weighted homicide rate of 23.2 per 100,000. Twenty-one of the 22 nations are in the Tropics, with the majority in the Central & Southern Africa region. Of interest, two nations in the Central & Southern Africa region reported HDI scores of

⁵ The Gini coefficient is a measure of statistical dispersion, measuring inequality among values of a frequency distribution. A Gini coefficient of zero expresses perfect equality where all values are the same (for example, where everyone has equal income) and a coefficient of 100 expresses maximum inequality (where one person has all the income).

Box 8.1.3 Homicide rates in tropical Latin America

The nations of tropical South America report significant variation in homicide rates, and in 2008 ranged from 2.9 per 100,000 in Peru to 52 per 100,000 in Venezuela.

In Colombia, the homicide rate fell from 69.7 per 100,000 population in 1995 to 33 in 2010. With support from the United States, Plan Colombia was implemented in the early 2000s to address, amongst other things, drug-related organised crime through better resourcing of anti-drug activities and stricter law enforcement. The area under coca cultivation fell from 163,300 hectares in 2000 to 81,800 hectares in 2008 and cocaine production declined by 35% (UNODC 2003). Homicide rates fell dramatically in this period. Colombia recorded a sharp fall in its homicide rate in 2003, and it has fallen steadily since then.

At the other end of the scale, homicide rates have increased markedly in Venezuela. The increase in both conventional and drug-related homicide is believed to be influenced by a corrupt, inefficient and politicised judiciary, an ineffective prison system due to violence and overcrowding, a corrupt and poorly paid police force, the presence of up to 15 million illegal weapons, and an official discourse that supports class warfare (The Economist 2010). Prior to 1999 the homicide

rate was steady at around 20 per 100,000 population, but has increased to 49 per 100,000 in 2009.

Homicide rates in Brazil have increased more modestly, up from 27 per 100,000 in 1995 to 31 per 100,000 in 2008. Combined, these factors have seen South America's homicide rate range between 30 and 35 per 100,000 population between 1995 and 2008.

The crackdown on drug-related crime in Colombia has seen a transfer of these criminal operations to Central America (Insight Crime 2011) where homicide rates have been trending up since 2003. For most nations in Central America the late 1990s was a period of declining homicide rates. Since then, although the timing has varied, most nations in the region have experienced a turning point, with homicide rates starting to trend up. Four of the eight nations in Central America report a homicide rate above 40 per 100,000 population in 2010. Nonetheless, Central America's homicide rate, at 26 per 100,000 in 2010, was relatively low given Mexico's weighting of almost 75% in regional calculations, with its homicide rate at 22 per 100,000. Excluding Mexico, Central America's regional homicide rate increased by nine, to 35 per 100,000.

more than 0.7 in 2004, and both of these nations reported less than four homicides per 100,000 population. However, both nations are small, and combined they represent less than 0.2% of the regional population.

The relationship between human development and homicide rates however is not consistent across regions, suggesting that other factors are also at play. For example, in 2004 South Asia reported relatively low GDP per capita of \$2,438 and yet, by a large margin, had the lowest homicide rate in the Tropics at 5.1 per 100,000. While there is no clear explanation for this, it is likely that cultural factors may contribute to the low homicide rate, as nations in this region are typified by a supportive communal life with strong family and religious values, and a cultural ethos which contributes to relatively compliant and cohesive communities (Currie 1985).

South America is another example and, to a lesser extent, Central America. Socio-economic conditions in these regions vastly exceed those in the African and Asian regions, yet high homicide rates prevail. This suggests different sets of factors are at play in these regions, including the presence and influence of major organised crime groups.

Organised crime and gangs

A youthful population can be a great asset for a nation, but it can also be a source of social instability. Most crime is committed by and against males between the ages of 15 and 30, and this demographic is more likely to be associated with gangs and organised criminal groups.

Globally, many of the nations with the highest homicide rates are also primary drug source or transit nations. The large majority of these nations are in the Tropics – in the Caribbean, Central America and South America. Since the mid-1990s Central America has been the major transit corridor for drugs entering the United States from South America. The United States Government estimates that 90% of cocaine arrives through the Central American corridor (World Bank 2011b).



Institute for Peace Promotion and Injury Violence Prevention, Universidad del Valle. Image: Ian Britton.

Along the transit corridor the value of illicit drugs increases as they get closer to the United States, and this higher value tends to correlate with higher homicide rates. In the first Central American city on the trafficking route the homicide rate was 12 per 100,000 persons in 2004. By the time drugs reach the final Central American city before entering the United States the price has increased by a factor of five and the homicide rate by a factor of three, to 41 per 100,000 (UNODC 2011). The greater financial stake for organised and violent crime groups contributes to higher homicide rates closer to the United States. Competition and disagreements between criminal groups, seizures by authorities and the threat of greater enforcement activity have historically been a root cause of lethal violence on the transit corridor.

Globally, drugs are a key focus of organised criminal activity. Nonetheless, other forms of inherently violent transnational organised crime also exist, notably people trafficking, though data on these activities are not as readily available.

Firearms

The availability of firearms is another factor that influences homicide rates. UNODC data for 108 nations (covering 50% of global homicides) reports that in 2010, 42% of homicides involved a firearm, with 74% of homicides in the Americas involving a firearm and 21% in Europe (UNODC 2011). In Africa, an estimated 35% of homicides involved a firearm in 2003 (UNODC 2005). Firearm-related homicide was considerably lower in other regions.

The recent history of armed conflict in many African and Latin American nations has increased the availability of firearms. The combination of a large number of guns in the civilian population, the demobilisation of ex-combatants into civil society (often with limited employment prospects), and a legacy of scores to be settled and reduced inhibitions about the use of violence can all contribute to higher homicide rates (Cole & Marroquín Gramajo 2009).

Rule of law

A nation's capacity to enforce the rule of law can affect homicide rates. Nations with strong and effective legal systems that are enforced and adjudicated independently and equally tend to have lower homicide rates. Conversely, factors such as corruption, an inability to prosecute offenders and a lack of prison facilities can foster a perception of impunity and contribute to high rates of homicide.

Effective law enforcement is resource-intensive, and this can lead to lower than desirable deployment in these activities, especially in developing nations. Where resources are scarce, low numbers of police officers can be exacerbated by inadequate training, high rates of illiteracy, substandard equipment and police corruption. In six Central & Southern African nations for which data are available, the ratio of police per 100,000 population ranges from 42 to 160, significantly lower than in developed nations which tend to have 400 to 500 police per 100,000 people (Barker 2010). These six nations have relatively high homicide rates, ranging from 17 to 37 per 100,000 in the 2004. A similar story emerges in some parts of Central America, though there is greater variability in the relationship as there are nations that, despite relatively high numbers of police per capita, report exceptionally high homicide rates.

In the Tropics, the three regions with homicide rates less than 10 per 100,000 in 2004 had more than 300 police per 100,000 people population (UNODC 2011).

Similarly, there is a link between the resourcing and effectiveness of the criminal justice system and homicide rates. Developed nations tend to have 10 to 18 judges per 100,000 population, while in Africa and Latin America/Caribbean the range tends to be three and eight per 100,000 respectively (UNODC 2011). Fewer judges mean there is a lower chance of conviction, especially as witnesses can disappear when cases progress slowly. The chance of a homicide resulting in a conviction is around 11% in Africa, compared to 56% in the United States, 66% in Oceania and 63% in Asia (UNODC 2005).

Conviction rates are as low as 2% in some parts of Central America (UNODC 2007).

Homicide and development

Homicide undeniably affects individuals and societies. The human costs, particularly in nations with limited social safety nets, can be significant for both the victim and perpetrator (if convicted) and their dependents, especially where they are a family's sole breadwinner. At a societal level, a greater risk of homicide can cause individuals to withdraw from social and commercial activities which can affect education, health and economic outcomes. High homicide rates can also influence a nation's skilled labour pool, with major consequences for growth prospects. The highest emigration rates for educated workers are from Central America and Africa, and both regions report high homicide rates (UNODC 2007). High crime and homicide rates can also influence investment in a region, which can have long term economic and employment impacts.

Looking forward

In the main, crime is the outcome of a limited range of choice and inequality of opportunity. As such, integrated policy frameworks that address social and economic dimensions of crime are likely to be more effective in reducing rates of violent crime and homicide in the long run. This could include policies aimed at employment growth, poverty eradication, and equitable income distribution in the future. Policies that improve the circumstances of those in society that are most vulnerable to becoming involved in violent crime are likely to have a positive impact on homicide rates.

Nonetheless, such policies need to be partnered with efforts to improve the effectiveness of police and judicial systems to ensure citizens are adequately protected, including from organised crime groups and gangs.

Corruption

The concept of governance relates to the manner in which public and private sector officials and institutions acquire and exercise authority to shape policy and provide goods and services. Good governance promotes equity, transparency, accountability and the rule of law, and can contribute to sustainable development outcomes (UNESCAP 2012). Poor governance systems increase the risk of power being misused for private gain (that is, corruption), in both the public and private sectors (World Bank 2006).

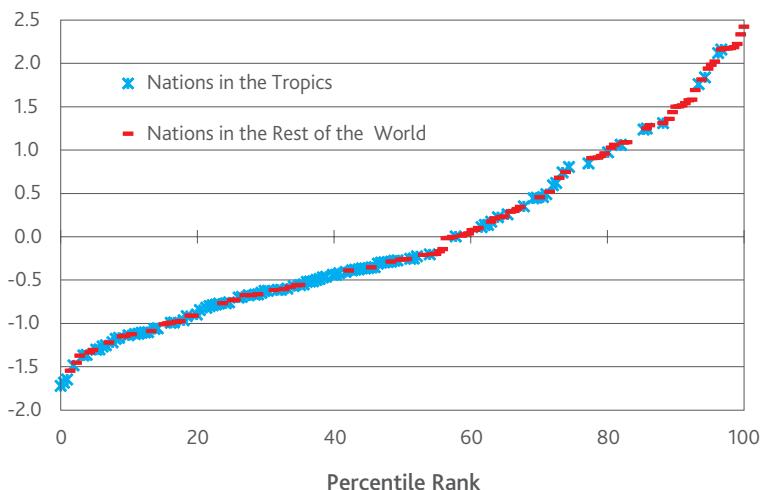
Corruption undermines political stability and, especially in developing nations, this can have impacts beyond national borders (Lewis 2007). The interpretation of what constitutes corruption varies across cultures and nations, but it commonly includes bribery, embezzlement, nepotism and conflict of interest (Slater 2011). Corruption tends to be more prevalent in nations where government is centralised, legislative and judicial institutions are weak, the rule of law is not strictly enforced, public service education requirements and wages are low, and where there is limited capacity to hold offenders to account (Furphy 2010).

The biggest obstacle to combating corruption is the difficulty measuring it, due to its clandestine nature. Victims' fear of retaliation and the perpetrators vested interest in secrecy generally result in non-disclosure. This has led to 'perceptions' being the most common measure of corruption. Despite criticisms regarding its subjective nature, perceptions have proved to be a reasonable indicator of the extent of corruption. Measuring scandals, investigations or prosecutions tend to reflect other factors such as freedom of the press, or efficiency of the judicial system rather than corruption (Transparency International 2011).

A number of corruption perception datasets are available, with the World Governance Indicators (WGI) 'Control of Corruption', 'Rule of Law' and 'Regulatory Quality' assessed here as measures of corruption and governance. WGI values range from -2.5 to 2.5, with higher values representing better performance with respect to the indicator.

Figure 8.1.4 World Governance Indicator, Control of Corruption, 2011

Governance Rating



Source: World Bank (2012), State of the Tropics project.

The WGI are recognised as being among the most carefully constructed and widely used governance indicators (see Box 8.1.4). Nonetheless, the indicators have limitations, and care needs to be taken in interpreting reported estimates and how they are used in decision making. Transparency International's public sector-focussed Corruption Perceptions Index (CPI) is another commonly cited measure of corruption⁷.

Governance indicators are often used by decision-makers in distributing aid, although this is often against the intentions of the creators of these indicators. The use of corruption indicators for the distribution of aid can also be resented, as many developing nations perceive them to have a private-sector and 'western' bias, with narrow, legal interpretations of governance. The argument is that this can obscure subtle but costly manifestations of poor governance which affect both developing and developed nations, particularly where there is an element

of state capture by powerful vested interests (for example, financial and media organisations) which impacts government decision-making (Arndt & Oman 2006).

Trends

Looking at 'Control of Corruption', in 2011 74% of nations in the Tropics had a rating of less than zero, compared to 45% in the Rest of the World suggesting that mechanisms to control corruption are less progressed in the Tropics. Figure 8.1.4 reports the 'Control of Corruption' ratings for 2011. The 2011 ratings

⁷ Transparency International's Corruption Perceptions Index is probably the most widely recognised governance indicator, but is not used in the assessment here due to its limitations with respect to time series analysis.

⁸ Regional estimates are calculated as the straight average of national scores in the region.

are largely unchanged since 2000, suggesting that perceptions of the control of corruption are relatively static. Globally, between 2000 and 2011 only seven nations reported statistically significant improvements in the 'Control of Corruption' indicator, two of which were in the Tropics and both in Central & Southern Africa.

For 'Rule of Law', in 2011 75% of nations in the Tropics had a rating of less than zero, compared to 41% in the Rest of the World. Globally, between 2000 and 2011 only ten nations reported statistically significant improvements in the 'Rule of Law' indicator, four of which were in the Tropics, across three regions. Although the Tropics' performs marginally better with respect to the WGI 'Regulatory Quality' indicator, the story is similar in that very few nations report statistically significant changes over time.

Of note, almost 90% of tropical nations in the dataset are classified as developing, compared to around 55% in the Rest of the World. Nations scoring poorly on perceptions of corruption are mainly poor or failed states affected by extended periods of conflict, ex-communist states or nations run on communist lines (The Economist 2011). In contrast, nations with the highest scores tend to be high income, developed nations.

At the regional level⁸ there were no statistically significant changes in the 'Control of Corruption', 'Rule of Law' and 'Regulatory Quality' indicators over the period 2000 to 2011 and, as such, only regional ratings for 2011 are reported in Table 8.1.6. In the Tropics the Caribbean performs best with respect to the 'Control of Corruption' indicator, with a rating in 2011 of 0.45 and eight of its 12 nations having a rating greater than zero, followed by Oceania and South East Asia. For the other regions in the Tropics, less than 20% of their nations have a 'Control of Corruption' rating greater than zero.

Oceania performs best with respect to 'Rule of Law' and, along with the Caribbean, has more than half of its nations reporting a positive rating. South East Asia is the next best

performed, and for each of the other tropical regions less than 15% of their nations have a rating greater than zero. South East Asia reports the highest 'Regulatory Quality' rating followed by the Caribbean and Central America. However, the Caribbean and Central America are the only regions to report at least 50% of nations with a 'Regulatory Quality' rating greater than zero.

Low ratings in many African nations reflects weak political and administrative institutions – often associated with prolonged periods of conflict – which contribute to poor governance systems, widespread nepotism and abuse of power. The influence of tribal, religious and geographic interests in public decision making processes have also negatively impacted governance and anti-corruption measures in these regions (Uwimana 2011). Nonetheless, several nations report good results, including Rwanda and Botswana (see Boxes 8.15 & 8.1.6)

Relatively high perceptions of corruption in many nations of Central and South America can reflect weak democratic institutions (often associated with a lack of independence), or being at an early stage of civic and institutional transition following years of authoritarian rule (Salas 2011). Weak institutions provide opportunities for corruption, and for organised crime to gain influence. It is not clear whether organised crime weakens the state through corruption or if corruption allows organised crime to flourish, but as long as both coexist the integrity of democratic institutions is at threat (Salas 2011).

Although Oceania performs relatively well, many developing nations in the region are characterised by poor governance and geographically dispersed populations. Vast distances combined with complex relationships between traditional and modern systems can affect the state's capacity to influence day-to-day decision making, and the effectiveness of accountability institutions in addressing corruption. This is especially the case in remote areas. For example, the traditional practice of gift-giving can be problematic, though whether it is corruption or culturally sanctioned will depend

Box 8.1.4 World Governance Indicators

The World Governance Indicators (WGI) framework defines governance as "the traditions and institutions by which authority in a country is exercised (Kaufmann et al. 2010). This includes (a) the process by which governments are selected, monitored and replaced; (b) the capacity of the government to effectively formulate and implement sound policies; and (c) the respect of citizens and the state for the institutions that govern economic and social interactions among them." For each of the three areas, two measures of governance are constructed.

The WGI are among the most widely used governance indicators, and are constructed using data reporting the perceptions of governance from a wide variety of sources, and organising them into clusters corresponding to six dimensions of governance, namely Voice and Accountability, Political Stability & Absence of Violence/ Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law and Control of Corruption (Arnt & Oman 2006).

The WGI also report margins of error to reflect the unavoidable imprecision in measuring governance, and which assist the user in interpreting and comparing results across nations and over time. WGI values range from -2.5 to 2.5, with higher values representing better performance with respect to the indicator.



Image: James Cook University.

Table 8.1.2 Selected World Governance Indicators, 2011

	Control of Corruption	Rule of Law	Regulatory Quality
Tropics	-0.35	-0.41	-0.39
Central & Southern Africa	-0.58	-0.70	-0.63
Northern Africa & Middle East	-0.89	-1.01	-0.98
South Asia	-0.65	-0.32	-0.41
South East Asia	-0.13	-0.11	0.17
Caribbean	0.45	0.20	0.12
Central America	-0.33	-0.50	0.07
South America	-0.48	-0.65	-0.44
Oceania	0.05	0.26	-0.42
Rest of the World	0.30	0.33	0.38

Source: World Bank (2012), UNHCR (2012), State of the Tropics project.

*Percentage point.

on the intent, scale and the public or private nature of the gift (Barcham 2007).

Natural resources & foreign aid

Corruption is more prevalent in developing nations and tends to be exacerbated when there are large financial inflows from natural resource development or foreign aid. Of 27 tropical, developing nations identified as being resource-rich (Baunsgaard 2012), 22 (81%) scored 35 or lower on Transparency International's 2012 CPI⁹, compared with 52% for non-resource rich developing nations in the Tropics. With a CPI score of 65 however, diamond-rich Botswana stands out as an exception (see Box 8.1.6).

A large proportion of global resource extraction occurs in developing nations, and host governments receive considerable revenue from license fees, royalties and taxes. Nonetheless, many

of these nations perform poorly on a range of social and economic indicators, suggesting the majority of the benefits from resource extraction accrue to a small elite, rather than the broader population. In the absence of a culture of transparency and institutions to combat corruption, extractive windfalls can easily be misappropriated for personal gain rather than being used to support nation-wide growth and development (Lewis 2007). For example, many developing nations in Africa with significant resource wealth and extraction revenues perform poorly in the United Nations Human Development Index.

The propensity for corruption appears most evident in oil producing nations with weak rule of law and state ownership of resources. This environment can foster a culture of rent-seeking by political leaders for personal gain, and lead to perverse social and economic outcomes due to structures and incentives that oil dependence creates (Karl 2004). As oil rents increase, so

does corruption, while political rights tend to deteriorate, especially where there is a high degree of state participation in oil production (Arezki & Brückner 2009). In many instances resource companies are complicit in corrupt activities through a lack of transparency in reporting production levels and payments to government.

Foreign aid, much like natural resources, can result in significant financial inflows and opportunities for large-scale personal gain by corrupt officials if governance is weak, at the expense of those most in need of assistance. In fact, without effective institutions aid is likely to have a detrimental impact on the quality of governance (Abuzeid 2009). This suggests that aid should first be directed to improving governance (e.g. supporting international agreements and initiatives on governance, or providing funding and technical support for governance reforms). Benefits will be maximised if the projects supported are limited to those where sound governance arrangements are in place. Research suggests that before 1997 increases in foreign aid were associated with higher levels of corruption or no change, and that, encouragingly, since 1997 the 'anti-corruption movement' has had some success, with increases in multilateral aid often associated with lower levels of corruption (Charron 2011).

Looking forward

As economic activity is increasingly globalised, so too is the transnational nature of bribery and corruption. Its eradication therefore requires international solutions through co-operation and shared responsibility. The World Bank and other major international institutions now target corruption as a major cause of underdevelopment, and provide assistance to affected nations to address factors underlying corruption. This includes

⁸ Regional estimates are calculated as the straight average of national scores in the region.

⁹ The CPI ranks nations on a scale from 100 (very clean) to 0 (highly corrupt). A score of 35 is chosen arbitrarily, but is intended to reflect a relatively low CPI score. The median CPI score in 2012 was 37.

introducing measures to combat fraud and black-listing companies that breach procurement guidelines. There is also evidence that donor nations have begun to give more importance to recipient nations' actions to curb corruption when deciding how to allocate multilateral aid (UNDP 2007), though the impact with respect to bilateral, strategic aid is less evident.

The Extractive Industries Transparency Initiative (EITI), implemented in 2003, is another example of a global scheme designed to improve transparency and accountability. This public-private sector initiative requires subscribing nations to publish all payments from extractive industry operators, and aims to ensure that these revenues contribute to long term economic and social development. The EITI has become the global standard in the extractives industry, and a model for international co-operation to other sectors (USIP 2010).

Box 8.1.5 Rwanda

Rwanda is one of the least corrupt nations in Central & Southern Africa, and is an example of what can be achieved with a commitment to strengthening political, judicial and administrative institutions and governance. Major anti-corruption reforms undertaken in Rwanda since 1997 include the introduction of the National Decentralisation Policy and the establishment of the Office of the Ombudsman, the Anti-Corruption Unit in the Rwanda Revenue Authority, the Auditor General and the National Tender Board (Chene 2008). Accepting bribes is now a criminal act.

At the operational level, measures to facilitate cultural change in the public sector included the introduction of codes of conduct and rules of disclosure for public officials, as well as education and training programs. Constitutional changes now also require high ranking public officials, from the President down, to declare their assets on assuming and leaving office.

Rwanda's judicial system was also reformed. Conflicts of interest were prohibited, minimum education requirements were raised and proof of integrity and a history of exemplary conduct became prerequisites for judicial appointments. All court positions were made vacant under the reforms and a merit-based selection process was introduced.

Rwanda is now also a signatory to a number of international conventions against corruption including the United Nations Convention Against Corruption, the African Union Anti-corruption Convention and the UN Convention against Transnational Organised Crime (Transparency International UK 2011).

Rwanda is one of the few nations globally to report statistically significant improvements in a number of World Governance Indicators, including 'Control of Corruption'.



Children in Rwanda. Image: Women for Women.



Jwaneng diamond mine, Botswana. Image: Esther Dyson.

Box 8.1.6 Botswana – resource rich and transparent

Botswana inherited a legacy of underdevelopment at independence in 1966. However, the discovery of minerals in the late 1960s transformed it from a poor to a middle income nation. Resource development in Botswana is driven by private sector investment, and policies are considered to be amongst the best in the world, with open and transparent mineral licensing and taxation regimes operated by a competent and honest institutional structure (Sebudubudu 2003). In 2012 Botswana's Corruption Perceptions Index score of 65 made it the least corrupt nation in Central & Southern Africa, a position it has held since Transparency International first reported data for it in 1998.

Mining is an industry that can be fertile ground for corruption, but in Botswana it has been a major driver of social and economic development. The inclusive nature of Botswana's development is, in part, attributable to good institutions and economic management and political stability, which have deterred corruption.

These factors, combined with the government retaining a major share of resource rents in taxes, royalties and dividends has provided the framework for inclusive growth. Botswana is not, however free of corruption. Following a series of high profile, non-resource industry-related corruption scandals during the 1980s and early 1990s the government established the Directorate on Corruption and Economic Crime (DCEC) in 1994. The DCEC is designed specifically to deal with corruption, and has powers to investigate, prevent and teach the public about corruption and economic crime.

The DCEC has brought a sustained focus on the issue of corruption in Botswana, and the success of its anti-corruption campaigning is reflected in the high number of reports it receives. It has provided ordinary citizens with the opportunity to report corrupt activities (IAACA 2012).

Botswana has been relatively open regarding receipts from the mining industry (Jefferis 2009), and has been a signatory to the Extractive Industries Transparency Initiative since 2007.

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A vertical strip on the left side of the page shows a blurry image of a Vietnamese school girl. She is wearing a white collared shirt with a yellow sash featuring three black stripes, and a dark green skirt. Her hair is pulled back.

Chapter 8.2

Governance | Gender Equality

'The education and empowerment of women throughout the world cannot fail to result in a more caring, tolerant, just and peaceful life for all.'

Aung San Suu Kyi

Summary of gender equality indicators

Indicator	Tropics	Central & Southern Africa	Northern Africa & Middle East	South Asia	South East Asia	Caribbean	Central America	South America	Oceania	Rest of the World	World
Ratio of Female to Male Adults (25+) with at least secondary education 1950-2010	0.3-0.7	0.4-0.5	0.2-0.6	0.2-0.7	0.3-0.8	0.7-0.9	0.7-0.9	0.7-0.9	1.1-0.9	0.8-0.9	0.7-0.8
Percentage (%) of women holding seats national parliament 1997- 2011	10.3-18.1	9.5-19.2	5.8-12.9	6.7-9.4	12.6-17.5	17.4-30.6	14.2-21.5	9.1-17	4.6-12.6	13.2-20.2	12.1-19.5

The link between equality and social and economic development is well documented, and improving wellbeing across society requires people to have similar opportunities with respect to education, employment and decision making. Improving opportunities for women is associated with clear improvements across a range of social and economic indicators. Healthy and educated women benefit their families, communities and nations.

Gender equality is achieved by changing cultural norms, beliefs and practices that discriminate between men and women. Attitude, beliefs, and practices that encourage gender inequality originate in the household, the community, and the workplace, and improving gender equality in these domains can positively affect the lives of men and women, boys and girls, and advance quality of life, personal autonomy, and economic and political freedoms.

The equality of men and women has been accepted as a fundamental principle of human rights since the adoption of the United Nations Charter in 1945.

Education is universally acknowledged to benefit individuals and promote national development. Educating girls and boys produces similar increases in earnings, opportunities and choices. However, educating girls has additional social benefits as it is associated with delayed marriage, lower fertility and improved health and survival rates for infants and children.

Indicators

Girls with secondary education – globally there has been considerable success in improving the access of girls to primary education. There is some indication however, that secondary level education may provide higher returns, especially for girls. Secondary education not only provides

economic returns but is also consistently associated with greater decision making power and increased mobility for women.

Women in national parliament – a principle of democratic government is that parliament should represent and express the will of the people. Civil society is considered more effective if parliament is widely representative of the population. Relative to their proportion of the population, women are under-represented in national parliaments, which can lead to a large proportion of the population being under-represented in national level decision making.

Women and education

Is it getting better?

Girls with secondary education - Fewer females have access to secondary education relative to males in the Tropics than in the Rest of the World, but the gap is closing. In 2010 the ratio of female to male adults with at least secondary education in the Tropics was 0.747, well below the ratio of 0.855 for the Rest of the World (inequality for women exists if the value is less than 1). Nonetheless the margin between the Tropics and the Rest of the World has decreased considerably over the past 60 years.

Women in national Parliament - Globally, the representation of women in many facets of society is improving. The proportion of women in national parliaments increased from 12.1% in 1997 to 19.5% in 2011. The improvement is broadly similar in the Tropics and the Rest of the World, increasing from 10.3% to 18.1% and 13.2% to 20.2% respectively.

Globally, the changing gender balance is having some impact on the policy agenda, but there is scope for much greater change.



Dafur. Image: Albert Gonzalez, UNAMID.

Women and girls represent 70% of the world's poor (UNIFEM 2013), earn only 10% of the world's income and own only 1% of the world's property (CARE 2010). Against this backdrop, creating equal opportunities for men and women in education, employment, access to health care and representation in decision making is fundamental to social justice, and is also a critical pathway to economic and social development (UN 2012).

Education is a key contributor to improving gender equality and is recognised as one of the most powerful instruments for reducing poverty and developing a foundation for sustained economic growth (World Bank 2013). However, access to education is not always equitable, and can be influenced by factors such as gender, income and race.

Increased participation by girls and women in education generates significant individual, family and societal benefits. Recognising this, a suite of global and regional programs have been developed to emphasise the importance of girls' education to improving gender equality and human development outcomes, and reducing poverty. The outcome of these programs is higher primary school completion rates for girls, and growing demand from girls for secondary education.

Higher levels of education create a greater range of opportunities, and can help to prepare and position women to take on transformative positions in society. Research demonstrates that, relative to primary education, secondary schooling is more consistently and strongly associated with increased decision-making, freedom and mobility for women (Malhotra et al. 2003). Therefore, understanding female participation in secondary education¹⁰ is a key indicator of gender equality.

Trends

Globally, the proportion of adult women that have undertaken secondary education is considerably lower than for males, but the gap is closing. Relative to the Rest of the World a considerably lower proportion of both men and women undertake

secondary school in the Tropics, and the ratio of female to male adults with secondary education is considerably lower (Figure 8.2.1). In 2010 the ratio of female to male adults with at least secondary education in the Tropics was 0.75, well below the ratio of 0.86 for the Rest of the World (inequality for women exists if the value is less than one). Nonetheless the margin between the Tropics and the Rest of the World has decreased considerably over the past 60 years (see Figure 8.2.1), largely due to significant improvements in the Tropics, where the ratio increased from 0.34 in 1950 to 0.75 in 2010. In the Rest of the World it improved from 0.79 to 0.83 over the same period.

The Tropics recorded steady growth in this gender ratio in the past 60 years to 2010, though improvements were particularly strong in the 15 years to 1995, driven by rapid improvements in South East Asia and, to a lesser extent, South Asia and South America.

Despite the Tropics being below the world ratio in 2010, four of the eight tropical regions recorded ratios of female to male adults with at least secondary education above the world ratio. Seven out of eight regions increased, at varying rates, while the ratio of Oceania was below the 1950 level. Nonetheless, Oceania reported the second highest ratio of the tropical regions in 2010. South America recorded the highest ratio of the tropical regions in 2010 at 0.99 and, along with Oceania, the Caribbean and Central America also have high ratios, at 0.94 and 0.90 respectively (see Table 8.2.1).

South East Asia reported the greatest improvement, increasing from 0.29 in 1950 to 0.83 in 2010. South Asia and Northern Africa & Middle East also reported strong increases over this period. Oceania

¹⁰Secondary education around the world is diverse, but generally refers to any academic or vocational education beyond primary school level. The United Nations now includes the first two years of secondary school in their definition of 'Basic education'. Students in secondary school can generally choose from a wider range of general and specialised study programs offering different levels of instruction and leading to different career paths. Some programs focus on preparing students for tertiary education, while others prepare them for direct entry into the labour force. Source: www.unesco.org

was the only region to report a decline in the ratio, falling from 1.06 in 1950 to 0.95 in 2010 (see Table 8.2.1). The decline in Oceania is due to a fall in the ratio in the United States of America (i.e. Hawaii), with all other nations in the region for which data are available reporting improvements, especially Papua New Guinea (though it was from a very low base) and Fiji. For the United States the ratio was still above parity in 2010, and the highest in the region.

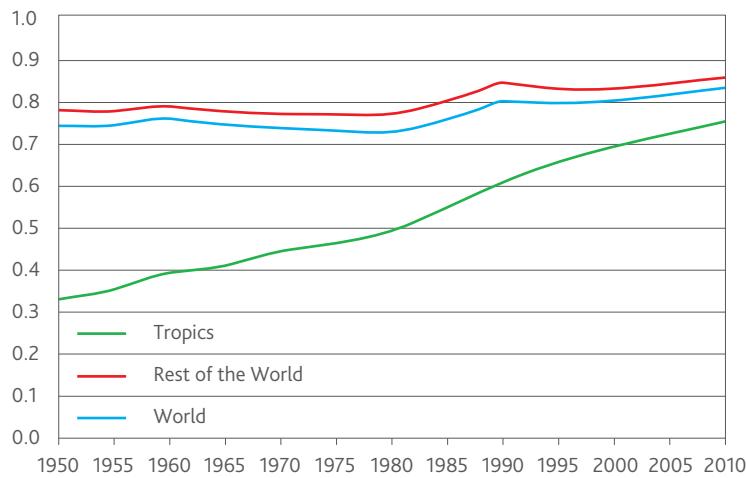
Steady improvement in the Tropics is being supported by a number of global programs which aim to improve educational opportunities and empowerment opportunities for women and girls. For example, UNICEF's African Girls Education Initiative (AGEI) started in 1994 to encourage more girls into schools, and has an underlying focus of learning by doing (Oxfam 2011). The success of AGEI was a factor in the establishment of the United Nations Girls Education Initiative (UNGEI) in 2000 – the first global partnership promoting gender issues in education. UNGEI promotes and supports initiatives which aim to improve the gender ratio of primary and secondary school attendees.

Other global programs supporting the education of girls and women over the past two decades include:

- The Adolescent Girls Initiative, launched in 2008 as part of the World Bank Group's Gender Action Plan, aims to help adolescent girls and young women to finish secondary school and make a successful transition from school to work. This initiative is being trialed in eight low income countries, five of which are in the Tropics.
- Education For All (EFA) is a global commitment, launched in 2000 and led by UNESCO, to provide quality basic education for all people. Through this program governments are encouraged to invest 4–6% of GNP and 15–20% of public expenditure on education, depending on demography and economic status. The EFA is linked to the Global Partnership for Education, which represents developing nations, donor government, NGOs and multilateral organisations and aims to improve education funding, planning and outcomes (UNESCO 2012a).

Figure 8.2.1 Ratio of female to male adults (25+) with at least secondary education*

Ratio (female / male)



Source: Barro & Lee (2013).

*The proportion of the 25+ female population with secondary education divided by the proportion of the 25+ male population with secondary education.

- The Coalition for Adolescent Girls brings together more than 30 international organisations targeting girls in poverty.
- CAMFED (Campaign for Female Education) aims to support girls' education and the empowerment of women through community-based programs in Africa.
- Because I am a Girl Campaign was launched by Plan International in 2006 and aims to fight gender inequality, promote girls' rights and lift girls out of poverty.
- UN Adolescent Girls Taskforce is co-convened by UNICEF, the United Nations Population Fund, the World Health Organisation, and the United Nations Fund for International Partnerships to improve interagency cooperation on programs that address the most marginalised and disadvantaged adolescent girls.

Barriers to education and equality

Initiatives to empower women and girls have improved education, employment, and health outcomes over the past 60 years, but high levels of gender inequality still persist in many parts of the world. Women and girls are more likely to live in poverty, earn less income and own less property than men. Women and girls represent just under two-thirds of the illiterate population in the world (at 64% and 61% of the illiterate population respectively) (UNESCO 2012b). Broad inequalities in households and society prevent women from fully participating in society and from achieving returns from engagements with education and the labour force.

Despite worldwide attention and increased funding for women and girls' education, barriers exist which prevent girls from starting, and if they start, completing secondary school. A survey of professionals and teachers working in education and development worldwide found that the main barrier to girls going to secondary school is poverty (49%)

Box 8.2.1 Measures of gender equality

A range of indicators are available to measure gender equality, and many of the composite measures include an education dimension. Nonetheless, actually quantifying the extent of inequality can be complex due in part to differential life expectancies of men and women.

The Gender Parity Index (GPI) is a measure of access to education for males and females and is usually based on enrolment rates in a given stage of education (e.g. number of males enrolled against number of females in primary, secondary, or tertiary education) (USAID 2012). The GPI is expressed as a rate, with a score below or above one indicating inequality. For men inequality exists if the rate is above one and for women inequality exists if the rate is below one. For the Millennium Development Goals equality is considered to be achieved with a GPI rate of between 0.97 and 1.03.

The Gender Inequality Index (GII) was developed in 2010 by the United Nations, and replaces two previous

measures: the Gender Development Index, and the Gender Empowerment Measure. The GII is a composite measure of loss in human development due to gender inequality. Inequality is reflected in three dimensions: reproductive health (adolescent fertility and maternal mortality); empowerment (parliamentary representation and educational attainment); and labour market participation. GII scores range from zero to one, with zero indicating equality and one indicating inequality. For example, the world average score on the GII is 0.492.

The Global Gender Gap Index is used by the World Economic Forum in its annual Global Gender Gap Report. This index examines the gap between men and women in four categories: economic participation and opportunity; educational attainment; health and survival; and political empowerment.

All three of these measures of gender equality suggest that the status of women has been improving over time.

followed by the undervaluing of girls (22%) (Fancy et al. 2012). Other barriers include negative parental attitudes towards school, the perceived quality of available schools, distance to the nearest school, girls' burden of chores and ongoing conflict or civil unrest.

Overcoming these barriers is a challenge for tropical nations, as many will experience some or all of these obstacles. Solutions proposed for keeping girls in school include scholarships, more (and better) schools, incentives for teachers, relevant curricula, better training and salaries for teachers, improved toilet facilities and the provision of free sanitary products (Fancy et al. 2012).

Nonetheless, poverty is the driving factor affecting whether children attend school, irrespective of improvements that may be made to schooling and education systems. Children from poorer households are less likely to attend school, with girls more likely than boys not to be educated due to poverty. An estimated 71 million children worldwide aged between 12–15 years did not attend secondary school in 2010, of which 53% were female (UN 2012).

Empowering women

Female empowerment is recognised as an important factor influencing the degree of gender inequality in a society. Women's access to health and education services is considered a necessary factor for female empowerment. Empowerment leads to increased economic opportunities for women, as well as access to transformative and decision making roles in households and society.

Education can provide the skills which enable women to more readily access and interpret information regarding health and disease, and this information can be critical during pregnancy and after childbirth. Education and health services empower women to take greater responsibility of their lives, including greater control and ownership of their bodies (USAID 2008). Women with higher levels of education can make better informed choices about work, marriage and children (World Bank 2012).



School girls, Bolivia. Image: World Bank.

Table 8.2.1 Ratio of female to male adults (25+) with at least secondary education*

	Ratio							Total difference (ratio) 1950-2010	Total difference (%) 1950-2010
	1950	1960	1970	1980	1990	2000	2010		
Tropics	0.34	0.40	0.45	0.49	0.61	0.69	0.75	0.41	121
Central & Southern Africa	0.35	0.29	0.27	0.33	0.40	0.46	0.54	0.19	54
Northern Africa & Middle East	0.18	0.20	0.21	0.25	0.36	0.48	0.58	0.40	217
South Asia	0.17	0.20	0.27	0.33	0.42	0.51	0.57	0.39	227
South East Asia	0.29	0.33	0.42	0.53	0.69	0.75	0.83	0.54	190
Caribbean	0.75	0.78	0.77	0.81	0.84	0.91	0.94	0.19	26
Central America	0.72	0.75	0.79	0.72	0.84	0.87	0.90	0.17	24
South America	0.66	0.70	0.76	0.84	0.96	1.00	0.99	0.34	51
Oceania	1.06	1.02	0.97	0.98	1.05	0.95	0.95	-0.11	-10
Rest of the World	0.79	0.81	0.77	0.77	0.85	0.83	0.86	0.07	9
World	0.75	0.78	0.74	0.73	0.80	0.80	0.83	0.08	11

Source: Barro & Lee (2013), State of the Tropics project.

*The proportion of the 25+ female population with secondary education divided by the proportion of the 25+ male population with secondary education.

Improved access and engagement with education have also assisted more women to enter the formal labour market. Women have increased their share in employment outside of the agricultural sector in developing countries, with a five percentage point rise recorded in the 30 years to 2010.

Self-employment opportunities for women also improved in the 30 years to 2010, and women own and run more businesses than ever before (FAO 2013). Business ownership for women in developing nations – often established with microfinance – provides tangible alternatives to the informal labour market and opportunities to apply business and other skills that would otherwise be underutilised. These businesses can generate income and wealth for their owners, as well as employment opportunities for other members of the community. Women are also considered more likely than men to reinvest money earned from employment into their

children's wellbeing, providing for education and health needs (UN 2010).

Looking forward

Improvements to women's and girls' lives have been immense in the past 60 years. Opportunities provided by higher levels of education can support women and girls to engage equally with men in society. Progress includes higher parity ratios in all levels of education, growth of businesses opportunities for women, greater freedom and mobility, and increasing numbers of women in decision-making and political roles. To advance gender equality further, female empowerment initiatives must aim to increase the number of women in secondary and tertiary education and in high-level formal employment.

In many societies men are increasingly being encouraged to use their influence in the household, in the workplace and in civic society generally, to engage in the deconstruction of gender stereotypes and discriminatory practices (UNESCO 2004). Men generally have a much higher share in upper-management including decision-making occupations emphasising the important role men have in balancing gender equality.

Many of the potential advantages to women from secondary education are conditional on culture and local social norms (Malhotra et al. 2003). Achieving equality for women and girls will be made possible by challenging the cultural traditions and perceptions of gender that influence discriminatory decision-making practices in legislation and social policy.

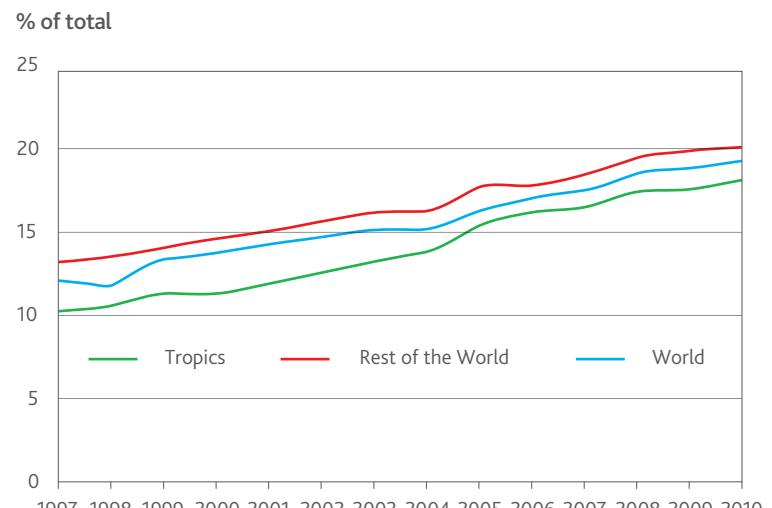
Women in national parliament

The proportion of women representatives in a country's national parliament¹¹ is an indicator of gender equality. Females typically represent more than half of a nation's population, but they tend to be significantly underrepresented in national parliaments. In only two of the 194 nations for which 2011 data are available did women hold more than 50% of seats and, globally, only 19.5% of seats in national parliaments were held by women (IPU 2012). Though significantly underrepresented as a proportion of the population, this is a solid improvement on the 12.1% reported in 1997, but still well short of the 30% targets suggested by various international bodies¹². It has been suggested that a minimum representation of 30% is needed to influence political processes and policy development in legislative bodies (Krennerich 2009).

A range of socioeconomic, cultural and political impediments are known to affect the rates of female representation in national parliaments (IIDEA 2005). Socio-economic obstacles include low levels of education and literacy, low labour force participation, the dual burden of career and family commitments and often a lack of financial support. The costs of political campaigning are high and many women do not have the means to be effective candidates (WEDO 2008). Higher labour force participation tends to improve financial resources and provides a source of political contacts necessary to campaign effectively. Cultural factors can range from social stereotyping, secularism, and patriarchal values to a basic lack of confidence to stand for election. The type of electoral system can also influence the proportion of women in parliament, as can candidate selection rules, political party ideologies and, at a personal level, a lack of political knowledge and experience.

Nonetheless, many nations are seeking to improve opportunities for women to hold public office and contribute to policy and civic development. As cultural attitudes and socio-economic factors are quite slow to change, political reforms are typically the most effective mechanism to improve representation in the

Figure 8.2.2 Women in national parliament*



Source: IPU (2012), State of the Tropics project.

short term. Reflecting this, gender quotas have been adopted by a number of governments and political parties to increase female participation. In 2011 seven of the ten nations with the highest proportion of women in national parliament had some form of gender quota (IIDEA 2013).

Trends

Globally, the representation of women in many facets of society is improving. In politics this is reflected in the increase in the proportion of women in national parliaments from 12.1% in 1997 to 19.5% in 2011 (see Figure 8.2.2). The improvement is broadly similar in the Tropics and the Rest of the World, increasing from 10.3% to 18.1% and 13.2% to 20.2% respectively, with the Tropics performing marginally better. Globally, greater female representation is being supported by the introduction of gender quotas in many nations, with 59 nations having a quota in 2011 (32 of which are in the Tropics) compared to only 17 (11 of which were in the Tropics) in 1997.

The gradual increase in representation at the global level is not universal, and there is considerable variation across nations. Six of the seven nations with no female representatives in their national parliaments are in the Tropics. Also, unlike the slight narrowing of the gap between the Tropics and the Rest of the World, the gap between the tropical regions is large and has been increasing over time. This is because of consistently low representation in South Asia while, in the Caribbean, representation has increased significantly. The female representation gap between South Asia and the Caribbean increased from 10.7 percentage points in 1997 to 21.2 percentage points in 2011 (see Figure 8.2.3).

¹¹ 'National parliaments' refers to single and lower houses of parliament. If a nation has an upper and lower house of parliament, data and commentary here refers to the lower house.

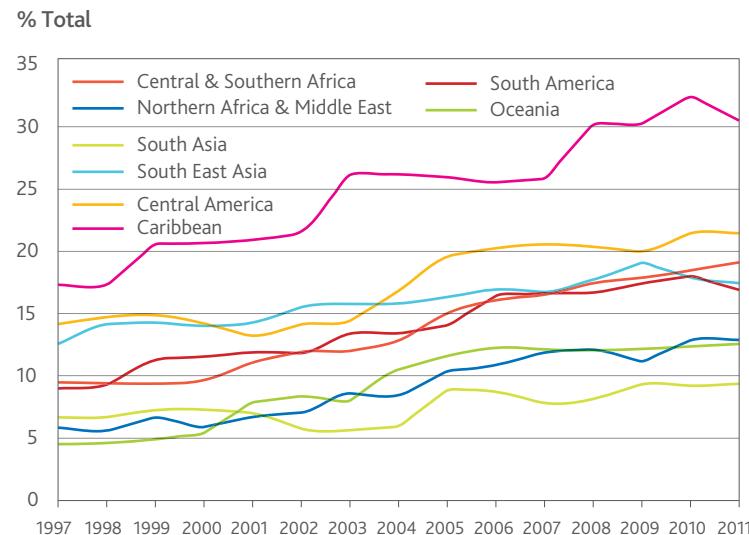
¹² During the United Nations Fourth World Conference on Women in 1995, 189 countries endorsed a target of 30% of seats in national parliaments being held by women. More recently, the United Nations Millennium Development Goal's set a target of 30% to be achieved by 2015.

In 1997 the Caribbean had the highest proportion of female representatives in national parliament in the Tropics at 17.4%, and retained this ranking through to 2011 when women made up 30.6% of representatives. In fact, the increase in the proportion of women in parliament in the Caribbean far exceeds that of the other tropical regions (see Figure 8.2.3) and the Rest of the World, and it is the only tropical region to exceed the Millennium Development Goal of 30% representation by 2015. The improvement has been driven by substantial increases in Cuba and Trinidad and Tobago. In Cuba's case progress has been associated with a government commitment to improve equality for women in all aspects of life.

At the other end of the scale, at 9.4%, South Asia had the lowest proportion of female parliamentarians in 2011, with a relatively small increase from the 6.7% reported in 1997. The Oceania region had the lowest representation in 1997 at 4.6%, increasing to 12.6% in 2011. This solid improvement is largely driven by French parity laws being implemented in French Polynesia and New Caledonia since 2001 (French Polynesia and New Caledonia are collectivities of France). These laws require political parties to include 50% of women on their electoral candidate lists. In elections following the introduction of the law the proportion of women representatives increased from 12% to 48% in French Polynesia and from 17% to 46% in New Caledonia (Bargel et al. 2010). Most other nations in Oceania, and particularly Pacific Island nations, continue to have low rates of representation, with four nations having no women in parliament and a further six with representation of less than 5%. Excluding French Polynesia and New Caledonia, representation in Oceania was only 2.5% in 1997, increasing to 3.4% in 2011.

In Central & Southern Africa the situation is far more encouraging. Coming from a relatively low starting point of 9.5% female representation in 1997, Central & Southern Africa achieved the second largest improvement to 2011, increasing by 9.6 percentage points to 19.1%. A number of

Figure 8.2.3 Women in national parliament – the Tropics



Source: IPU (2012) State of the Tropics project.

nations in the region have achieved substantial improvements through a phase of post-conflict political and civil development, which has often included constitutional reform. (see Box 8.2.4)

The widening gap between the tropical regions suggests major differences in cultural, socio-economic and political characteristics. Limited progress in South Asia and many nations in Oceania suggests the barriers to reform are more entrenched in these areas.

Women's activism

Increasing female representation worldwide is influenced by a broad range of factors including improvements in the socio-economic status of women in many societies. National and international efforts to improve education, employment opportunities and the status of women in society have increased the capacity and confidence of women to contribute to

political and civil life in decision making roles. This has been supported by the civil rights and women's movements which have exerted pressure on political parties and institutions to introduce changes which facilitate more equitable representation in parliaments and other institutions. For example, groups such as the United Women of Tanzania, the Collectifs Pro Femmes/Twese Hamwe (Pro-Femmes) in Rwanda and the Namibian Women's Manifesto have been influential in the introduction of reform agendas (Waring 2010). These (and other) groups have also provided education and training on parliamentary procedures and campaign management to build capacity and confidence in women to participate more effectively in the electoral process. In many nations, women's movements are also actively engaging in constitutional reform, contributing to the development of legislation and political rules that are more conducive to gender equality.

Box 8.2.2 Types of electoral systems

There are three main types of electoral systems: majoritarian, proportional representation, and mixed. The majoritarian system is the oldest and simplest electoral system. With this system there is usually only one seat per electoral district and the candidate that wins the majority of the votes is elected. Under this system cultural factors can have an influence when political parties are dominated by one gender as the candidate selection process may be skewed to favour the political aspirations of that gender.

In proportional representation systems parliamentarians are elected in multi-member electoral districts. The number of seats a political party wins is proportional to its overall share of votes received. The larger number of seats available in each electorate is an incentive for political parties to consider a range of candidates who are likely to

appeal to a broad spectrum of voters, including women. As a result the proportional representation electoral system tends to deliver parliamentary representation that is broadly indicative of the society it serves. Where legislated quotas exist, such as the French 'law on parity', the proportional representation system can be even more effective in improving female representation. Nonetheless, party leaders can influence the gender and positioning of their candidates on electoral lists and, therefore, to some extent, gender representation in parliament.

The mixed electoral system combines elements from both the proportional and majoritarian systems. Typically part of the legislative assembly is elected using the majoritarian system, and the balance under some proportional representation arrangement.

In the case of Rwanda, in 2000 the Constitutional Commission was established to draft a new constitution. The Commission engaged in a series of consultations which allowed significant input by women. The women's umbrella organisation Pro-Femmes was particularly effective, and the new constitution requires that at least 30% of posts in all decision making institutions be held by women (IIDEA 2005).

Electoral systems

A range of cultural, social and political factors influence the outcome of elections, and it is recognised that the choice of electoral system can affect how women engage in the political process (see Box 8.2.2).

The design of the electoral system influences the way votes are translated to seats in parliament. The key variables in the system are the electoral formula (proportional representation, majoritarian, or mixed), district magnitude (number of seats in each electorate) and the ballot design (IIDEA 2008). The practices of political parties and the manner in which they interact with the electoral system also come into play. For example, the single seat in each electorate which is characteristic in majoritarian systems encourages political parties to select candidates they consider to be the most electable. In comparison, proportional representation allows political parties to put forward a larger number of candidates, which is generally more conducive to party lists including a broader cross section of society, including women.

During the past three decades there has been a significant increase in the parliamentary representation of women in nations with proportional representation, but only modest increases in those with majoritarian systems (Squires 2010). In 2011, in nations with proportional representation women held 22% of all seats in national parliaments compared to 18% in nations with a majoritarian system and the rate of growth has been significantly faster in



Image: Sikarin Thanachairiy, World Economic Forum.

the proportional representation electoral system over the past 14 years.

That a significant number of nations in the Rest of the World (43 of 89) use the proportional electoral system compared to tropical countries (32 of 103) is likely to be a factor contributing to the variance in parliamentary representation of women between the two areas.

Nonetheless, proportional representation cannot guarantee greater female representation, and its impacts are maximised when favourable conditions prevail, including the presence of well organised political parties. Proportional representation has been found to be less effective when political systems are dominated by a large proportion of independent politicians.

Nations tend to change their electoral systems infrequently, though in recent years many post-conflict nations, notably in Africa, have undertaken constitutional reform, as have several nations in Central and South America. An outcome of this is that many nations are reviewing potential electoral systems. Many of these reforming nations have adopted proportional representation systems as they tend to deliver parliamentary representation that is more indicative of the wider community. Other positive features of proportional representation which make it popular are its tendency for high voter turnout, combined with fewer opportunities for biasing outcomes through gerrymandering.

Quotas

A gender quota is a mechanism to increase the number of women in parliament. There are several ways to implement quotas (see Box 8.2.3), and over the past 30 years they have become increasingly popular as an option to increase the proportion of women in national parliaments.

Quotas were first introduced by political parties in Western Europe in the 1980s to consolidate earlier increases in representation achieved

from improved education and employment opportunities and the women's movements. Through the 1990s and early 2000s legislative quotas appeared in many African and Central and South American nations. In many instances women's activist movements were behind the introduction of quotas, which were seen as the only tool capable of overcoming deep seated cultural and socio-economic barriers inhibiting increased representation. Also, in post-conflict nations, the need to rebuild basic structures of civil society has provided an excellent opportunity to progress the equality agenda, including through the use of quotas (see Box 8.2.4).

Of the 109 nations in the State of the Tropics report identified as fully or partially in the Tropics, data are available for 103 and, of these, 11 had legislated gender quotas in 1997, increasing to 32 in 2011. Of the 89 nations of Rest of the World for which data are available, six had legislated quotas in 1997, increasing to 27 in 2011 (IIDEA 2005).

Of the 59 nations with legislated quotas in 2011, 18 had reserved seats quotas (with an average quota of 20%) and 41 had candidate quotas (with an average quota of 34%). Thirty-three of these nations had female parliamentary representation above 20%, and 20 of these (61%) were in the Tropics, with seven having a reserved seat system and the other 13 using candidate quotas.

The effectiveness of quotas is not guaranteed, as in 2011, 41 of the 59 nations with quotas had representation below mandated or implied levels. The type of electoral system, attitudes of political parties, monitoring effort and penalties for non-compliance all impact the success of quotas. In 2011, 14 of the 18 nations with reserved seat quotas (78%) complied, and non-complying nations tended to be close to the quota figure. In contrast, only 5 of the 41 nations with candidate quotas (12%) had the number of women in parliament as implied by their quota, and often there was a significant variation. In the Tropics, 10 of the 13 nations with reserved seat

Box 8.2.3 Quotas

Gender quotas aim to increase the political representation of women in parliament and can be constitutional, legislated or voluntary party-based quotas.

Constitutional quotas are enshrined in the basic law of a nation, while legislative quotas are introduced through legislation. Common forms of constitutional and legislative quotas include candidate quotas (where political parties must put forward a minimum proportion of female candidates) and reserved seats (where a nominated proportion of seats are reserved for women). Though legally binding, the success of candidate quotas in increasing the number of women in parliament depends on the ability of candidates to actually go on and be elected. The success of candidate quotas also depends on the extent of compliance monitoring and, importantly, the consequences of non-compliance. Reserved seats may be contested by election, filled by appointment or allocated to political parties in proportion to the number of seats won in an election.

Voluntary quotas are not legally binding and are usually initiatives undertaken by political parties to field a minimum percentage of female candidates.



Parliament in Accra, Ghana. Image: Jonathon Ernst, World Bank.

quotas (77%) and 2 of the 20 nations (10%) with legislated candidate quotas achieved their quota target.

This suggests that in the absence of penalties for non-compliance the candidate quota target is essentially aspirational, and political parties have no incentive to change their behaviour. Costa Rica is a tropical nation which successfully increased representation from 16% in 1997 to 39% in 2011 using candidate quotas, though this only occurred once political parties were monitored and incurred penalties for non-compliance (IIDEA 2005).

Cultural factors

Over recent decades the status of women in most societies has improved across a broad range of socio-economic indicators ranging from health outcomes to education and employment opportunities. In nations with no formal gender-specific barriers to election to parliament it would be reasonable to expect this to translate to a substantial improvement in the representation of women in parliaments. However, most parliaments continue to be male-dominated owing to cultural, political, socio-economic and institutional factors. In many nations, including developed nations, women's access to parliament continues to be affected by attitudes about women's role in society, a lack of support by political parties and bias among the electorate, particularly where political and cultural leadership has historically been a male preserve (Fraenkel 2006).

Public attitudes to the role of men and women in society vary markedly across nations. For example, attitudes to whether it is preferable for women to focus on home activities varied from 24% to 64% in a 2009 survey across 18 Latin American nations (Latinobarómetro 2009). Compared with 2004 survey results, the lower and upper results were largely unchanged, though the regional figure fell from 43% in 2004 to 38% in 2009. In 2004 six nations reported more than 50% of the population preferring women

to focus on the home, falling to two nations in 2009. Attitudes about whether men are better political leaders were largely unchanged with a range of around 20% to 50% and a regional figure of 33% in 2009 (up from 32% in 2004). Despite this, 17 of the 18 nations have quotas and seven have elected female presidents since 1990. This highlights that a broad range of factors are at play in determining the number of women in parliament.

To improve women's parliamentary participation it is recognised that an essential ingredient is a supply of motivated candidates, though in many nations cultural barriers can inhibit this. For example, the patriarchal control of political parties can make it difficult for women to gain entry into politics, and women are less likely to participate if elections tend to be marred by violence (Waring 2010).

The Caribbean is a region where cultural factors seem to have had a strong and positive influence on representation, and it consistently has the highest proportion of female parliamentarians of the tropical regions. The increase is driven by Cuba, and has been achieved without quotas.

Cuba's constitution guarantees women and men equal economic, political, social and cultural opportunities. Additionally, following the 1996 World Conference of Women the government initiated a broad ranging program to improve the status of women in society, backed up by a requirement for the annual reporting of progress. Implementation of the program was supported by the Federation of Cuban Women (FCW), which provided educational programmes and worked to improve the rights of women. Significantly, the FCW boasts a membership of around 85% of the female population aged over 14 years (Cuba Solidarity Campaign 2010). The program has also contributed to improving women's labour force participation, education and economic status which have contributed to their improved cultural, social, and political standing.

Impacts of increased representation of women in parliament

An implicit goal of improving the gender balance in national parliaments is to influence policy development to be more inclusive and reflective of the needs and aspirations of women, including issues of special concern such as family, health, education and sanitation. It is suggested that societies that elect large numbers of women tend to be more gender-equal in other respects than societies that elect fewer women (Wangnerud 2009), as the changing gender balance is having some impact on the policy agenda, even if evidence of a greater influence on policy implementation is mixed.

In most nations the proportion of women in parliament is increasing, though the gender re-balancing has not typically translated to meaningful change in the balance of power in many parliaments (IIDEA 2005). This may be because, as well as numbers, effectiveness is influenced by the degree of 'newness' to political processes, with a positive correlation between experience and effectiveness (Jeydel & Taylor 2003). In many nations there is also a tendency for women not to be promoted to positions of power and, where they do become ministers, the perception is they are allocated to portfolios dealing with social issues.

This is not to suggest an absence of power rebalancing. For example, women make up more than 50% of the parliament in Rwanda and there is evidence of cultural change, with women being appointed to a range of parliamentary committees and senior positions, including deputy speaker. At the policy agenda level women's issues are now raised with greater ease, and more regularly. However, the influence of more women in parliament on policy implementation in Rwanda is less evident, and suggests this area of the parliamentary process is more affected by a government's broader commitment to promote women's rights (Devlin & Elgie 2008). A number of significant legislative changes, such as the removal of prohibitions on

Box 8.2.4 Women in Rwanda's parliament

Rwanda is an example of a post-conflict nation that has successfully used parliamentary quotas to improve gender equality. Following the brutal genocide in 1994, 70% of the population was female. In November 1994 a transitional government was formed, and ruled until the first elections in 2003. The transitional government initially appointed eight of the 70 parliamentary seats to women, increasing this to 19 of 74 seats by 2000 (Devlin & Elgie 2008).

In 2003 Rwanda's new constitution included a quota assuring women a minimum of 30% of posts in all decision making bodies, or a minimum of 24 seats in parliament. These seats were to be contested in women only elections, where all candidates were women and voting was restricted to women. In the 2003 election 39 women were elected to parliament. That is, 15 women were elected to non-reserved seats, and women made up 49% of lower house representatives (IIDEA 2005).

The election result suggests that factors other than the quota system were at play, and had in fact been at play since the end of the genocide. The sharp drop in the male

population saw women move into traditional male roles in the economy and society generally, with a subsequent impact on the potency of the traditional patriarchal system. Combined with the re-emergence of local women's organisations (which had disbanded during the genocide), these were positive impacts for the status of women in society.

Women's groups lobbied for gender equality provisions in post-conflict governmental and administrative systems, and mobilised women candidates by educating and preparing them to participate in the political process. The support of a dominant political party, the introduction of the proportional representation electoral system and a reserved seats quota all acted to create an environment conducive to women being elected.

With many of the major political, socio-economic and cultural obstacles overcome this is exactly what occurred in the 2003 elections. Following the most recent election in 2008, women currently hold 45 of 80 seats (56%) and Rwanda has the highest proportion of women in parliament globally.

women inheriting land and new laws against gender-based violence, have been passed since 1996.

Although not ideal, meaningful gender equality policies can be introduced without a large proportion of female parliamentarians. For example, the proportion of women in Ghana's parliament is consistently below 10%, yet it has passed a number of laws regarding domestic violence and human trafficking which have improved the rights of women.

Looking forward

In most parts of the world there is increasing recognition of the importance of establishing gender equality, even if the process of achieving it tends to be slow. In terms of political equity, the number of women parliamentarians is likely to continue to increase, as is their effectiveness as they become more experienced, confident and influential in implementing their policy agenda. The fact that in 1998 there were only eight elected female heads of state, and that it increased to 19 in mid-2013 suggests this process is well underway.



Members of Parliament, Rwanda. Image: Rwanda Government.

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Laos.

Image: Bart Verweij, World Bank.



Chapter 8.3

Governance | Infrastructure

Summary of infrastructure indicators

Indicator	Tropics	Central & Southern Africa	Northern Africa & Middle East	South Asia	South East Asia	Caribbean	Central America	South America	Oceania	Rest of the World	World
Gross capital formation 1980-2011 (% GDP)	23 - 25	19 - 20	25 - 26	21 - 35	30 - 29	21 - 14	23 - 25	20 - 21	21 - 20	23 - 22	23 - 22
Access to improved water source 1990-2010 (% of population)	67 - 81	45 - 60	54 - 59	70 - 91	70 - 88	79 - 85	83 - 94	87 - 95	66 - 63	82 - 93	76 - 88
Access to improved sanitation 1990-2010 (% of population)	35 - 50	23 - 28	21 - 29	21 - 37	42 - 68	66 - 67	64 - 82	66 - 78	64 - 62	57 - 73	49 - 63

Infrastructure is the basic physical and organisational structures needed for a society and economy to function. It includes transport services (road, rail, air and port), water supply, sewers, energy networks and telecommunications, and can be funded from both public and private sources. Improvements in infrastructure can improve productivity, income and health.

The development and maintenance of infrastructure is considered essential for economic growth. Functionally it facilitates the production and distribution of goods and services and the provision of basic social services such as schools and hospitals. From a strategic perspective, spending on infrastructure represents an investment in a nation's future capacity.

Infrastructure that provides clean drinking water and effective sanitation is essential to the well-being of communities and nations. In many nations rapid population growth and urbanisation combined with budget constraints have often placed limitations on water and sanitation infrastructure.

Indicators

Gross capital formation - This indicator monitors the proportion of current economic activity that is being invested for longer term economic and social returns. It includes private and public outlays on additions to fixed assets plus changes in the level of inventories (physical stock).

Improved water source - Access to social infrastructure such as an improved water source can have significant impacts on a community, particularly with respect to health outcomes. Clean and safe water is considered the single most important determinate of public health. Improved water sources dramatically improve water quality.

Improved sanitation facilities - Sanitation refers to the provision of facilities and services for the safe disposal of human wastes, including through services such as garbage collection and wastewater disposal. Sanitation promotes health through prevention of human contact with the hazards of wastes. Inadequate sanitation is a major cause of disease. Improving sanitation is known to have a significant and beneficial impact on household and community health.

Capital formation

Is it getting better?

Gross capital formation – Worldwide, the rate of gross capital formation has been declining at an average of 0.1% of GDP per annum. Conversely, the Tropics have shown an upward trend in gross capital formation, growing on average by 0.5% of GDP per annum. The performance of the Tropics varied substantially with some regions displaying higher growth and variability than others. Maintenance and appropriate utilisation of capital will be vital for sustaining economic growth and improving wellbeing into the future. Nations with more effective institutions, secure property rights and non-corrupt governments tend to invest more in physical and human capital, to use these factors more efficiently, and to have higher income.

Access to improved water – Although the gap has narrowed, less people have access to safe drinking water in the Tropics than in the Rest of the World. In 2010 around 88% of the global population had access to

drinking water from an improved source, an increase of 2 billion people since 1990. In the Tropics the proportion of the population with access to safe drinking water increased from 67% to 81% between 1990 and 2010.

Access to improved sanitation – Sanitation is a major issue in many tropical nations, especially those with rising populations and increased urbanisation. Globally, sanitation coverage increased from 48% of the population in 1990 to 63% in 2010, and the number of people with access to improved sanitation facilities increased from 2.5 billion to 4.3 billion. In the Rest of the World the served population increased by 1 billion in the 20 years since 1990, reaching 2.8 billion in 2010. In contrast, the number of people with access to improved sanitation facilities in the Tropics increased from 0.7 billion to 1.4 billion.

Nations and regions in the world develop in different ways and at different rates. Economic growth is occurring in some regions of the Tropics at a rapid rate. Indonesia and Brazil now have a higher life expectancy than members of the British nobility did at the beginning of the 20th Century (Weil 2009). What contributes to economic and social growth, and why does it vary between nations and regions?

A key way to evaluate a nation or region's economic growth prospects is to measure investment in the tools and infrastructure that facilitate economic and productivity growth.

In this case, capital refers to physical, not financial capital. Nonetheless, access to finance – and debt finance – will be critical for many infrastructure projects to proceed. Gross capital formation tells us about how nations are investing in physical assets. It includes private and public outlays on additions to fixed assets plus changes in the level of inventories (physical stock) (see Box 8.3.1). Fixed assets include land improvements; plant, machinery and equipment purchases; and the construction of roads, railways, schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Capital does not include non-reproducible assets such as natural forests, land, and mineral deposits.

Essentially, this indicator reports how much economic activity is invested rather than consumed, and does not take into consideration the extent of past investment in physical capital assets (that is, the existing stock of physical capital).

Fluctuations in gross capital formation are an indicator of future business activity, business confidence and the pattern of economic growth. In times of economic uncertainty or recession, business and government investment in fixed assets (new buildings, machinery etc.) is often delayed or reduced as it ties up additional capital for a long interval of time, with a risk that it will not pay itself off (and fixed assets may be also be scrapped faster). Conversely, in times of robust



Kenya. Image: Doreen Mbalo, Sustainable Sanitation Alliance.

economic growth, fixed investment tends to increase, as it is more likely an investment will be profitable.

Understanding how tropical countries have invested in their past and how they are investing in their future will help us determine future social and economic capacity in the Tropics. Capital accumulation (among other economic variables) is significantly influenced by distance from the equator (Ram 1997). Underinvestment could result in long term environmental, social and economic consequences. Additionally, capital formation as a single indicator should be combined with some measure of effectiveness to truly understand the impact of infrastructure investment on economic growth.

Most human activities rely on some past capital investment, whether it is the homes that people live in, the roads or airports they use, their place of work or the buildings and other infrastructure used by governments to deliver services.

Trends

Gross capital formation

Worldwide the proportion of GDP which is accounted for as gross capital formation tends to be between 20% and 24%. In 2011 the figure was at the lower end of the range, with 20.7% of global GDP invested in capital formation, somewhat below the 30 year average of 22.5% (see Figure 8.3.1). The private sector typically accounts for around two-thirds of this capital investment, with the remainder sourced from the public sector (Everhart & Sumlinski 2001). As a percentage of GDP, capital formation in the Tropics has shown a strong upward trend over the past 30 years, driven by increases in South East Asia and, more recently, South Asia. In the Rest of the World there has been a slight downward trend over the past 30 years.

Capital formation as a proportion of GDP has varied substantially across and within the regions of the Tropics over the past 30 years (see Figure 8.3.2). There was also substantial variation

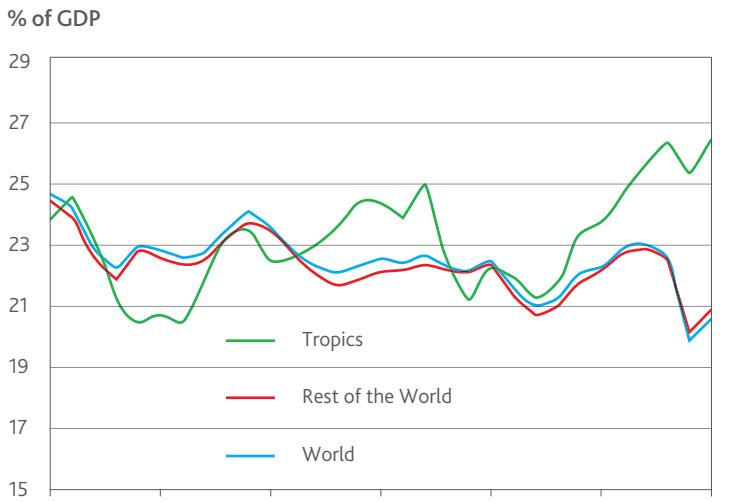
temporally – often over very short timeframes – reflecting prevailing economic and political conditions in regions. From a modest base of 22% of GDP in 1981-85, South Asia reported the greatest increase in capital formation in the Tropics, increasing by 14 percentage points to 36% in 2006-10.

Even though it was coming from a high base, South East Asia reported strong growth in capital formation's proportion of GDP in the early to mid-1990s. This was followed by a marked downturn in the late 1990s as the Asian Financial Crisis spread across the region. Capital formation as a proportion of GDP in South East Asia has only recently returned to its longer term average rate of around 30% (this is well above the global longer term average of 22.5%). South Asia experienced a period of rapid growth in capital formation as a proportion of GDP in the first decade of the 21st century supported by strong investment in the services sector in India (see Box 8.3.3). In Northern Africa & Middle East

the proportion can be volatile and is affected by the scale of investment for large resource sector projects. At the other end of the investment scale, there has been a significant and sustained decline in gross capital formation as a proportion of GDP in the Caribbean since the 1980s. Other regions have shown year to year variability, but have displayed more modest trends.

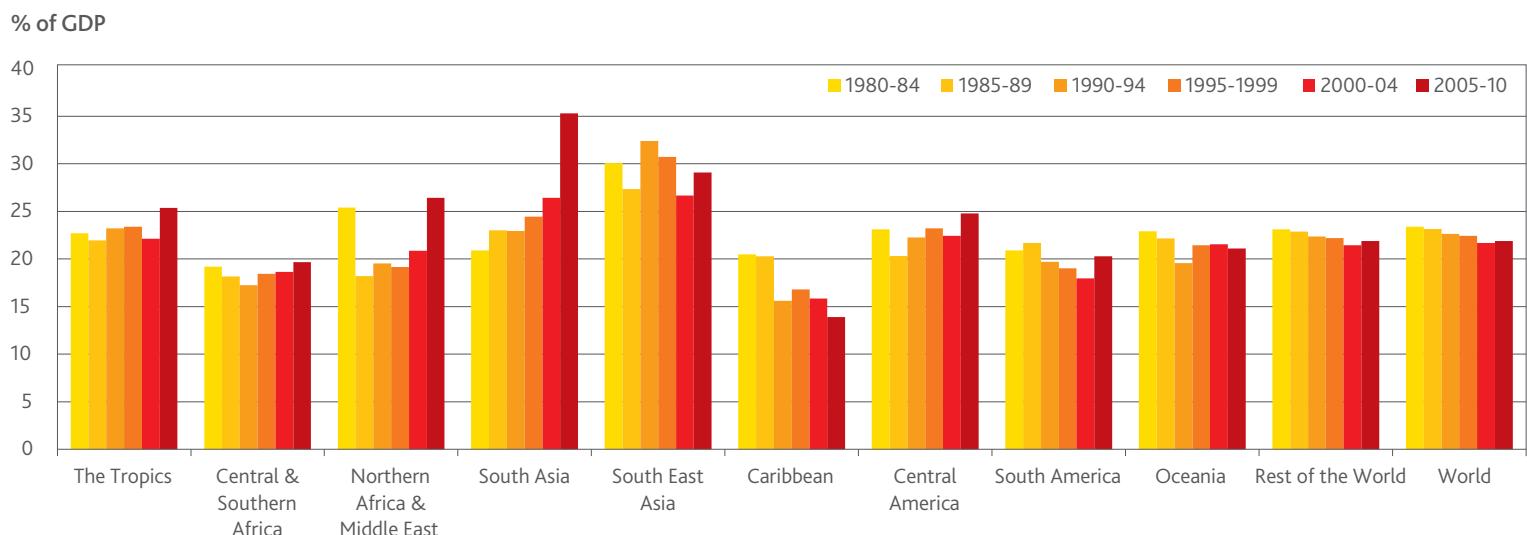
Overall though, in the past 30 years the difference between regions in the Tropics has increased, affected by different policies and economic growth trajectories.

Figure 8.3.1 Capital formation



Source: World Bank (2013), State of the Tropics project.

Figure 8.3.2 Capital formation – the Tropics



Source: World Bank (2013), State of the Tropics project.



Barelang Bridge, Indonesia. Image: Soham Banerjee.

Box 8.3.1 Measures of capital formation

Capital formation is the addition to a nation's capital stock, and is often referred to as investment. Common measures of investment are gross fixed investment and gross fixed capital formation. These measures capture additions to the capital stock, and do not take into account depreciation in the value of the existing capital stock. Investment is undertaken by both the private and public sectors, and is called capital formation to distinguish it from financial investment.

Definitions of the common measures are:

Gross fixed capital formation: includes land improvements; plant, machinery, and equipment purchases; and the construction of roads, railways, schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings.

Gross capital formation: consists of outlays on gross fixed capital formation plus net changes in the level of inventories.

Drivers of investment in capital formation

Strong investment in capital formation tends to demonstrate confidence in medium to longer term economic and political conditions. Available data report that although capital formation as a proportion of GDP has been rising in the Tropics, it is highly variable within and across regions.

Many factors affect gross capital formation in the Tropics, including the price of primary commodity exports, private external financing, foreign debt, and local governance arrangements, all of which impact a nation's or region's ability to invest in or secure external capital (Greene & Villanueva 1991). Outside of the financial sector, foreign aid, civil unrest and extreme weather events and disasters will also contribute to the ability of a country to invest in the future.

Gross capital formation has an important role in sustaining GDP, and is considered to be more important for economies in earlier stages of development (Madsen 2002). Large scale investments in nation building infrastructure such as airports are important drivers of capital formation (See Box 8.3.4)

Private fixed capital formation

Private investment plays a very important role in gross capital formation – particularly in developing nations (Madsen 2002) – and is the largest and most variable component of gross capital formation. Private sector investment is driven by commercial principles, and is considered to be more efficient and productive than public sector investment, and therefore more likely to underpin and sustain economic growth. Research has demonstrated that private investment plays a larger and more important role in economic growth than public investment (Tanzi & Davoodi 1997), notwithstanding that development encompasses more than economic growth.

Box 8.3.2 Globalisation of capital

Globalisation refers to the growing integration of national economies and societies, so that no society is isolated or remote from changes and developments in other societies (Dossani & Kenney 2007).

There have been huge increases in the value of cross-border capital transfers (mostly financial) in recent times, including the expansion of foreign direct investment by trans-national companies. The International Monetary Fund reports that, worldwide, the stock of foreign direct investments has increased from 8% of GDP in 1989 to 22% in 2003 (Patterson et al. 2004). There have also been global shifts in production and consumption, notably the rapid shift of production

activities from developed to developing nations over the past few decades. This may well account for the Tropics maintaining or increasing capital formation.

A key advantage of globalisation for developing economies is that it encourages foreign investment, but it also creates global scale risks that are beyond a nation's control, but which can have major impacts on economic performance and stability (e.g. the Global Financial Crisis). Unless open markets are combined with secure property rights and stable government, increased economic connectivity with the Rest of the World may have negative economic impacts (Milanovic 2003).



Hong Kong. Image: Steve Wedel.

The available data for private sector capital formation are insufficient to make regional comparisons within the Tropics or between the Tropics and the Rest of the World. However, based on the available data (representing 40% GDP in the Tropics), private investment in fixed assets in the Tropics ranged from 13–19% of GDP. This is consistent with research which suggests that, globally, private sector investment in fixed capital is the major component of capital formation (Reinhart & Khan 1989).

Private investment in capital is influenced by a number of factors. High domestic inflation and external debt appear to have a negative impact on private investment rates while solid rates of productivity, economic growth and public investment have a positive relationship with private capital formation (Madsen 2002).

Although private investment is considered the most important component of capital formation, there is clear evidence that public and private investments are complementary (Fisher & Turnovsky 1998). Public sector investment provides necessary 'enabling' infrastructure (roads, electricity, schools) which have a strong influence on the productivity of private sector capital formation. Similarly, research from OECD nations reports a positive relationship between public capital formation and growth in labour productivity (Nourzad & Vreize 1995). The long term economic benefits of investment in public infrastructure have particular relevance for tropical nations, and particularly for developing nations which tend to have an infrastructure deficit, where under-investment by the public sector can constrain both economic and social development. Public capital formation is often reduced in times of financial stress to ease debt burdens. Given tropical nations generally have high debt burdens, there is the risk that a lack of investment in public infrastructure may constrain private sector investment, and subsequent economic growth prospects.

Infrastructure effectiveness

Increased capital investment does not always lead to stronger economic growth. Despite rising capital formation in many tropical nations there have also been high rates of depreciation on the capital stock as a result of poor maintenance, unnecessary discard and underutilisation (Bu 2006). These are major issues as they limit the effectiveness of capital investment to promote long term growth.

The 1994 World Development Report focused on infrastructure for development and raised a number of issues around appropriate investments in infrastructure, monitoring and maintenance (World Bank 1994). It estimated that maintenance expenditures of US \$12 billion, invested at the right time, would have saved road reconstruction costs of US \$45 billion in Africa in the decade to 1994, and that poor maintenance of power and water supply systems that is inherent in many tropical nations reduces service quality and increases costs for users, and hence undervalues the initial investment.

Inefficient use of infrastructure can be responsible for more than 25% of the difference in economic growth rates between some economies. Coupled with lower rates of investment than in other tropical regions poor maintenance of capital stocks has been a major factor in relatively slow rates of social and economic development in sub-Saharan Africa compared with South East Asia (Hulten 1996).

Another reason why capital investment does not lead to stronger rates of economic growth in some tropical nations may be corruption. Research suggests that widespread corruption is associated with high public investment in infrastructure projects, but lower spending on maintenance and operation (Tanzi & Davoodi 1997). This suggests that public investment and aid programs focused on delivering new infrastructure – without considering the funding needed for ongoing maintenance – may have

a limited impact on longer term economic growth. Additionally, investing in quality governance systems and strengthening the role and independence of institutions which monitor and maintain capital investments will facilitate returns to investments in public sector infrastructure programs.

The geography and climate of the Tropics affects the contribution of capital to economic growth, as roads, bridges, harbours and electricity networks as well as houses and other buildings are particularly vulnerable to extreme events such as tropical cyclones (Wilbanks et al. 2007).

Weather and climate can affect infrastructure in other ways. The rate of deterioration of the external shells of building structures is often weather-related, depending on how they are constructed (Wilbanks et al. 2007). The Tropics is also characterised by diverse weather conditions; constantly warm temperatures, high humidity, extreme rainfall and high levels of evaporation (Galvin 2007), all of which potentially contribute to faster deterioration of capital assets than in temperate regions. The onset of climate change is likely to exacerbate these conditions and lead to even faster depreciation of the value of capital assets.

¹³ The Asian Financial Crisis began in July 1997 when the government of Thailand was forced to float the Thai baht due to lack of foreign currency to support its fixed exchange rate. This was followed by the devaluation of currencies throughout the region and subsequent economic downturn (Richardson 1998).

Box 8.3.3 Capital formation in India

Increased capital formation in India during the past two decades is part of a strategic development program to create and maintain high rates of economic growth (Acharya 2007). In the decade to 2010 India averaged real GDP growth of 7.4% per annum, compared with 3.3% worldwide and 4.1% across the Tropics. During this time India increased its gross capital formation as a proportion of GDP from 24% to 36% (see Figure 8.3.3).

In 2006 India was the most successful developing economy with respect to attracting private infrastructure investment, accounting for 15% of the total private investment in developing countries (Harris 2008). Despite this massive investment, India is still facing an infrastructure deficit if it maintains its current growth trajectory.

The services sector – The service (or tertiary) sector is the part of an economy which includes all economic activities not covered by the agricultural, mining or manufacturing sectors. It includes activities associated with the supply of water, electricity and gas, transport and communications, wholesale and retail trade, finance and insurance, business and personal services, and community and social services. The services sector is where Indian investment and growth has been centered in the past two decades.

To maintain strong rates of economic growth though, more investment will be needed. Telecommunications has accounted for 64% of investment in infrastructure from 2001-06. In 2008, more than 2 million people had access to phone services, compared with only 35,000 in 2002. Transport infrastructure is an important component of investment totaling 34% in 2006. However, investment in energy and water has been falling (<17%) and this is where the lag is considered to be. Very few cities in South Asia have continuous access to water and power which is a major constraint to future development.

The contribution of various programs and investments to India's growth is debated, though it is clear there is some relationship between increased capital investment (particularly in the services sector) and recent solid economic growth.

For India to sustain high levels of growth the private sector will need to invest in water and power, and broaden its trade beyond the current emphasis on services into a wider variety of goods, production and trade (Harris 2008).

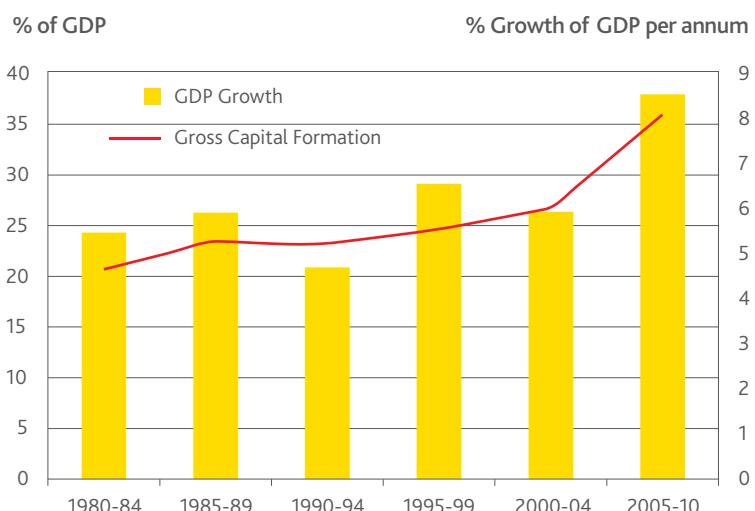
In the past, the Indian government has financed most of India's infrastructure development, however it does not have the financial resources to meet the growing nation's needs. In 2013, the Indian government set a target of attracting \$500 billion in private infrastructure spending in the next five years (PwC 2013). The government is encouraging investment in infrastructure through further liberalising foreign investment, extending tax holiday periods and developing public private partnerships

Looking forward

Ongoing investment and maintenance of capital stocks is critical for the social and economic development of all nations. However, to optimise the return on investment, timing is critical (to ensure capital utilisation rates are sufficient to warrant the investment) and there is a clear need to budget for ongoing maintenance to maximise the asset life. Evidence suggests that nations with strong institutions and governance, and secure property rights invest more in physical and human capital, and subsequently use these factors more efficiently to achieve higher levels of income (Alfaro et al. 2003).

To ensure that scarce (especially public) capital is invested in projects that deliver the greatest benefits to society it will be critical that broader outcome-based measures of effectiveness are developed to assist policy makers and financiers assess economic, social and environmental outcomes.

Figure 8.3.3 Gross capital formation and economic growth in India



Source: World Bank (2013), State of the Tropics project.

Box 8.3.4 The air transport industry in the Tropics.

Airports are among the most important infrastructural elements of modern cities and nations. The air transport industry plays a vital role in connecting nations and contributing to trade and economic growth, especially in industries which rely on rapid transit times such as tourism, logistics and high-tech manufacturing.

In the Tropics the number of airline passengers (an indicator of investment and growth in this industry) grew from 183 million to more than 400 million in the decade to 2010 (ICAO 2013). Despite this rapid growth, only 13% of air travellers worldwide were carried on airlines based in the Tropics. The vast majority of air travel still occurs on North American and European airlines.

Nonetheless tropical airport hubs are playing an increasingly important role in global air transport,

particularly those in South East Asia. In 2010, Hong Kong's Chek Lap Kok International Airport became the world's biggest cargo hub, exceeding Memphis (USA).

Air travel and the number of major airports have been growing quickly in the Tropics in the past 15 years, particularly in South East Asia. South East Asia now has four major hub airports at Hong Kong, Kuala Lumpur, Bangkok and Singapore, which have invested in major expansions to allow increased air traffic and provide access to more destinations throughout Asia, Europe and North America (Hom sombat et al. 2011). The number of passengers carried in South East Asia has more than doubled since the turn of the century, from 94 million to more than 200 million (ICAO 2013).

External to the financial system, the impacts of climate change are likely to increase the vulnerability of tropical assets and infrastructure to damage or destruction. As many tropical nations are at earlier stages of development than those in the Rest of the World, they have the opportunity to invest now in climate resilient and sustainable infrastructure and other capital.

Capital investment is not the only driver of economic growth: education, rising equality, science and technology, foreign investment and the global economy also have important roles in shaping development. Nonetheless, growing the stock of public and private sector assets in tropical nations will be vital to ongoing economic growth and social development into the future.



Hong Kong Airport.

Access to improved water sources

Water is essential to all life on Earth. At a base level human existence depends on access to ample clean water while, at the societal and individual levels, access to reliable and affordable water is integral to a healthy and productive life. The consumption of water containing pathogenic organisms or toxic chemicals, and not having enough water for hygiene, are the principal impacts on human health. Water is also essential to the health and vitality of natural ecosystems, and the ecosystem services they provide to society (UNDP 2006) (See Chapter 3).

Two billion additional people gained access to drinking water from an improved source between 1990 and 2010, yet there are still almost 800 million people without access to this basic requirement. Almost all of these people live in developing nations, and the majority in rural areas (UN 2012). The most serious consequence of not having access to safe drinking water is the increased likelihood of sickness and death from preventable water-related diseases, particularly

in young children. This can have significant social, cultural and economic costs (Gleick et al. 2001).

Water quality can be affected by a range of factors, including pollution from domestic and industrial sources, poor sanitation and hygiene, inadequate infrastructure and geogenic contamination of groundwater¹⁴ (UNICEF-WHO JMP 2011). In many developing nations rapid population growth and urbanisation combined with budget constraints have often placed a strain on water infrastructure, and contributed to water related diseases which are amongst the most common causes of illness and death.

Trends

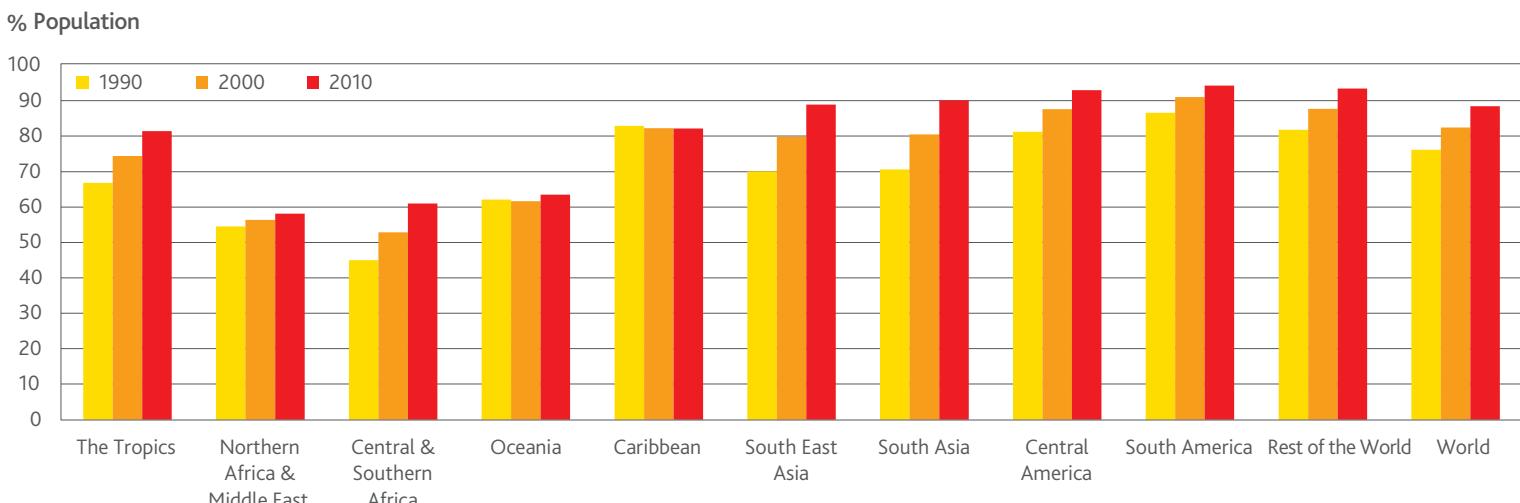
Comprehensive statistics on safe drinking water are generally unavailable as it is complicated to measure and definitions vary. Nonetheless, the Joint Monitoring Program (JMP) of the United Nations Children's Fund and World Health

Organization have developed the proxy indicator 'use of an improved drinking water source' as a measure of access to safe water (see Box 8.3.5). This measure has a tendency to overestimate the number of people with access to safe drinking water, but provides a reasonable measure for comparative purposes.

In 2010 around 6 billion people, or 88% of the global population, used an improved drinking water source, an increase of 2 billion people since 1990 when it was 76%. In the Tropics the proportion of the population which used an improved drinking water source increased from 67% to 81%, while in the Rest of the World it increased from 82% to 93%, meaning the gap between the two regions narrowed by three percentage points.

Half of the additional 2 billion people that gained access to an improved drinking water source live in the Tropics, with the number increasing from 1.3 to 2.3 billion people in the 20 years to 2010.

Figure 8.3.4 Use of an improved drinking water source



Source: UNICEF-WHO JMP (2013), State of the Tropics project.

In the Rest of the World the number of people increased from 2.7 billion to 3.7 billion.

In the Tropics, in three of the eight regions, more than 90% of the population had use of an improved drinking water source in 2010, namely South America (93%), Central America (93%) and South Asia (90%) (see Figure 8.3.4). A further two regions had rates higher than 80% – South East Asia (89%) and Caribbean (82%). In contrast, coverage is low in Northern Africa & Middle East (58%), Central & Southern Africa (61%) and Oceania (63%).

In terms of improvements over time, the smallest gain was made in Oceania where the proportion of the population using an improved drinking water source increased by one percentage point (to 63%) in the 20 years to 2010. Nonetheless, this translated to an additional 3 million people using an improved drinking water source. The result in Oceania is driven by Papua New Guinea (PNG), where the large population in rural, remote and often inaccessible areas can make infrastructure development costly and problematic (WaterAid 2013). A general lack of access to clean water and sanitation may be some of the key reasons behind PNG's high infant and child morbidity and mortality rates (ADB 2012). If PNG is removed from the analysis, coverage in Oceania increases to 91% in 1990 and to 95% in 2010.

South Asia and South East Asia stand out for significant improvements in the proportion of the population that uses drinking water from an improved source, which increased by 19 percentage points in both regions in the 20 years to 2010, to 90% and 89% respectively (see Figure 8.3.4). Other regions to report solid improvements include Central & Southern Africa where it increased from 45% to 61%. Although starting from a relatively low base, improvements in Northern Africa & the Middle East have been modest, and this reflects a number of factors, including political instability, high population growth in urban and slum areas and the low priority given to improving water services in budget allocations. In addition,

the costs to supply water in this region are relatively high, due in part also to the difficulty of regulating prices charged by private small-scale providers of water (UNEP 2010).

In South America and Central America, where coverage was already high in 1990, gains have been more modest, at 8.1 percentage points and 10.8 percentage points respectively.

Rural/urban disparities

The United Nations Millennium Development Goal to halve the proportion of the global population without sustainable access to safe drinking water was achieved five years ahead of schedule (UN 2012). As encouraging as this is, a large proportion of the global population still does not have access to safe drinking water and challenges to improving access remain, especially in rural areas where rates tend to be markedly lower than in urban areas and in urban areas of developing nations which are experiencing rapid population growth.

Globally it is estimated that around 96% of the urban population had access to safe drinking water in 2010, compared with 80% in rural regions (see Figure 8.3.5). Although significant, this gap has narrowed by 17 percentage points since 1990. To some extent this has been influenced by slower population growth in rural areas, rather than infrastructure improvements. Nonetheless, the urban/ rural distribution of people that gained access to drinking water from an improved source between 1990 and 2010 was relatively equal, with an additional 1.2 billion people in urban areas, and 1.1 billion in rural areas. However, almost 85% of the 780 million people estimated to not have access to an improved water source lived in rural areas in 2010 (WHO 2012a).

In the Tropics 89% of the urban population used an improved drinking water source in 2010, compared to 73% in rural areas (see Figure 8.3.5). In Northern Africa & the Middle East and Central & Southern Africa the gap between

urban and rural areas is more than 30 percentage points, and in Oceania it is 49 percentage points. In each of these regions less than 50% of the rural population use drinking water from an improved source.

Rural areas have lower population densities which are often widely dispersed, and economic activity tends to be lower compared with urban areas. This can make the delivery of safe drinking water more expensive on a per capita basis, and contributes to relatively low access rates in rural areas. The fragmented nature of political representation for people living in rural areas (even where the majority of the population may live in rural areas) can also mean that securing financial commitments to provide safe drinking water are difficult. The distribution of international aid also appears to be a factor, with the proportion of water and sanitation aid going to rural areas falling from 27% in 2003 to 16% in 2008 (UNICEF-WHO JMP 2011).

In urban areas the major issue has not been changes in access rates, but changes in the absolute number of people with access. In 1990 the global urban access rate was already high at 95%, and has since increased to 96%. With rapid urbanisation however, this translates to an additional 1.2 billion urban dwellers using drinking water from an improved source. At the same time, the urban population without access to safe drinking water has increased from 107 million to 137 million due to large numbers of people living in informal settlements or slums.

¹⁴ Geogenic contaminants refer to naturally occurring elevated concentrations of certain elements in groundwater which have a negative health effect on humans consuming this water. Arsenic and fluoride are the most widespread geogenic contaminants in groundwater worldwide.

Effects of poor water quality on health

Safe water for drinking and other purposes is vital for the good health and well-being of humans and ecosystems. Approximately 3.5 million deaths related to inadequate water supply, sanitation and hygiene occur each year, predominantly in developing nations (UNESCO 2012). In addition to having sufficient quantities, water quality is also a concern, as any microbial or chemical contamination can have significant health, environmental, social or economic impacts. Relative to having access to adequate quantities of water, water quality has received far less public attention and investment in recent decades (UNESCO 2012).

Significant progress has been made with respect to access to safe drinking water globally, but recent research suggests that JMP's definition of an improved water source (and therefore 'safe' water) is not sufficient to ensure that water is at low risk or free of contaminants. In addition to the 780 million people relying on water from unimproved sources in 2010, it is estimated that 1 billion people accessing water from improved sources could also be facing significant sanitary risks (Onda et al. 2012).

Water-related pathogens can be transmitted to humans by ingestion, skin contact or through vectors (see Box 8.3.6). At the household level it is the transmission of waterborne and water-washed disease that is most closely related to poor water supply or quality (WHO 2012b). While water-related diseases have largely been eliminated in developed nations, they remain a major risk in much of the developing world.

Poor water quality can increase the risk of diarrhoea, which kills around 1.5 million children under the age of five every year (UNESCO 2012). Cholera, an acute diarrhoeal disease, is a significant public health issue in many regions, and globally the number of reported cases increased by 130% between 2000 and 2010, although this was driven by a significant outbreak in Haiti following the 2010 earthquake

Box 8.3.5 UNICEF-WHO JMP measures of improved drinking water source

The JMP method assesses the final source of water prior to use as an indicator of whether it is safe or unsafe. If water is sourced from an improved source it is deemed to be 'safe', while water from unimproved facilities is deemed to be 'unsafe'. According to the JMP, an improved drinking-water source is one that, by the nature of its construction, adequately protects the source from outside contamination, particularly faecal matter.

Improved drinking water sources include piped household connections inside the user's dwelling or plot, public taps and standpipes, borehole and tube wells, protected springs and dug wells and rainwater collected and stored in containers. Piped water on premises is considered the optimal service level as this water tends to be treated, and provides the most convenient supply.

Unimproved drinking water sources include unprotected dug wells and springs, surface water (river, dam, lake, pond, stream, canal, irrigation channel) and vendor-provided water (carts and tanker trucks).

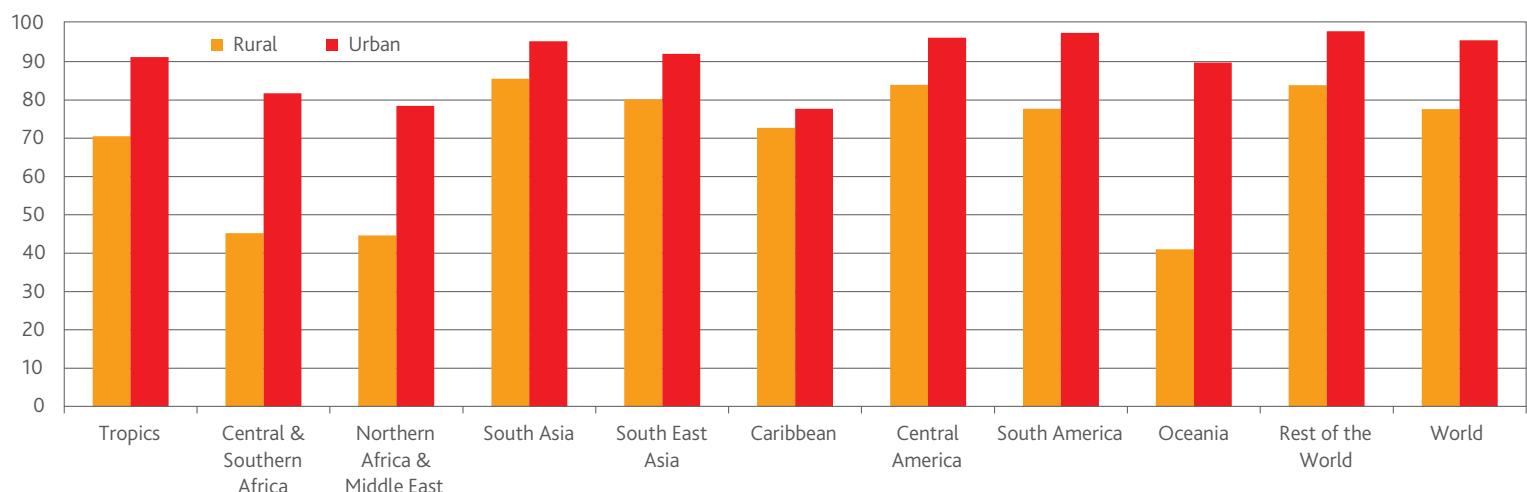
The JMP methodology is useful in estimating the number of people that have access to safe drinking water, but it does not consider important parameters – other than the water source itself – that will influence how safe or accessible water is. For example, the JMP methodology does not assess water quality or the availability of adequate quantities of water. Another important aspect is accessibility, as the distance to a water source or the travel time spent to access the source may inhibit the actual volume of water that is available for use (UNICEF-WHO JMP 2012).



Safe, clean water in Benin. Arne Hoel, World Bank.

Figure 8.3.5 Access to improved water in urban and rural areas in 2010

% Population



Source: UNICEF-WHO JMP (2013), State of the Tropics project.

(UNESCO 2012). Nations with a high incidence of peri-urban slums, refugee camps and exposure to humanitarian crises tend to be at greater risk of cholera outbreaks. Typhoid, which is transmitted through polluted water, remains a serious public health problem in South Asia, South East Asia, Africa and South America (Crump & Mintz 2010), and globally there were an estimated 13.5 million cases in 2010 (Buckle et al. 2012).

Arsenic and fluoride occur naturally in groundwater, sometimes at concentrations dangerous for humans. As groundwater use increases so too does the potential for large scale public health impacts. Although the number of fatalities is smaller than for waterborne pathogens, a significant number of people are at risk. For example, around 130 million people are at risk of consuming groundwater with arsenic concentrations above global standards (UNICEF-WHO JMP 2011). Long term exposure to arsenic in drinking water can cause skin lesions and lead

to cancer. Fluorosis is a widespread public health problem and high fluoride concentrations in groundwater have been reported in Asia, South America, the Middle East and Northern Africa. Fluoride poisoning, in its severest form, causes skeletal damage to bones and joints (Godfrey et al. 2010).

The presence of piped water infrastructure – which is often used as an indicator of improved water supply – does not guarantee that water is fit for human consumption. Population growth, inadequate and aging infrastructure and climate change impacts can influence the quality and availability of safe water. Processing systems often operate intermittently or at a fraction of their capacity due to poorly maintained pipes, illegal connections and deliberate reduction of water pressure in pipelines to conserve water. This can lead to stagnant water and micro-organism growth (Lee & Schwab 2005). Water utilities in most regions across the Tropics report less than 24 hours of service a day (Latin America

and the Caribbean – 22 hours per day, South East Asia – 20 hours per day, and South Asia – 11 hours per day). Continuity of urban water services is most variable in sub-Saharan Africa, and can be as low as six hours per day, while in South Asia daily average service continuity is less than 10 hours per day (UNICEF-WHO JMP 2011).

Gender disparities

Access to drinking water also has a gender dimension, as in almost three-quarters of households without on-premises access, women and girls have the primary responsibility for collecting water (UNICEF-WHO JMP 2011). It is estimated that girls and women in developing nations spend 40 billion hours every year hauling water, spending as much as eight hours a day, and carrying up to 40kg of water (Cap-Net & GWA 2006).

In the Tropics this problem is more pronounced in sub-Saharan Africa, where water collection times of more than 30 minutes per trip are common, particularly in rural areas (UNICEF-WHO JMP 2011). The long term consequences of this burden can be quite significant, as it can inhibit involvement in education and opportunities to engage in productive work and income generation, as well as social and political activities.

If the time needed to collect water is considered in assessing whether a source is improved, access is significantly lower than is currently reported. In sub-Saharan Africa for example, if 30 minutes is used as the cut-off, coverage drops by eight percentage points (UNICEF-WHO JMP 2011). Research also indicates that if the round trip to collect water is more than 30 minutes, households tend to collect less water, increasing the risk that minimum daily requirements for drinking and good hygiene practices will not be met (UNICEF-WHO JMP 2011). Close contact with water also means that people collecting water are more susceptible to waterborne diseases (Cap-Net & GWA 2006).

Looking forward

By 2015 it is estimated that 92% of the world's population will have access to safe drinking water. This is extremely positive but it still means that more than 600 million people from the world's poorest nations will still not have access to safe and clean water (WHO 2012a).

Median government expenditure for sanitation and drinking water is just one third of that for health and one sixth for education (WHO 2012a). In many nations it seems policies and programs place far too little emphasis on ensuring adequate financial and human resources to maintain and expand access to improved water sources.

A focus on some of the more basic interventions such as household level water treatment and safe storage can provide widespread health benefits at a relatively low cost. Point of use technologies such as the treatment of water with disinfectants or chlorine just prior to consumption, are an example of household treatments used in areas where centralised systems have been ineffective (Montgomery & Elimelech 2007).

Looking forward, the provision of safe drinking water for rapidly expanding urban, peri-urban and slum populations will be a major consideration for planners in tropical nations.

Box 8.3.6 Water-related disease

Water has a profound effect on human health, both as a means to reduce disease and as a medium through which disease-causing agents may be transmitted. Water-related diseases are frequently linked to poor sanitation, low hygiene standards and low volumes of water quantity. Transmission routes are classified into four major categories: water-borne, water-washed, water-based and water-related vectors. The first three are associated with lack of access to an improved domestic water supply.

Water-borne diseases are contracted by the ingestion of drinking water contaminated by human and animal waste containing pathogenic bacteria or viruses. The most common are cholera, typhoid, amoebic and bacillary dysentery and other diarrhoeal diseases. These illnesses are particularly prevalent in areas lacking adequate sanitation facilities.

Water can also transmit toxic chemicals which have been linked to cancer and organ failure. These toxic substances may be naturally sourced (such as arsenic and fluoride) or sourced from human activities (for example, pesticides). Compared to the global importance of waterborne disease, toxic substance risks and impacts tend to be quite regionalised.

Water-washed diseases occur when there is insufficient clean water for washing and personal hygiene or when there is skin or eye contact with contaminated water sources – most often faecal contaminants. Diarrhoeal diseases and trachoma (an eye infection) are the more common diseases in this group.

Neglected tropical diseases such as schistosomiasis (a parasitic worm carried by freshwater snails) and dracunculiasis (guinea worm) are spread by organisms that develop in water and then become human parasites either through skin contact or ingestion of drinking water.

Water-related vector diseases are not typically associated with water supply or quality. The spread of these diseases is facilitated by insects – notably mosquitos – that breed or feed near water. In many instances the large-scale development of water systems has created favourable conditions for these vectors. Malaria and dengue fever are two of the more well-known vector borne diseases that are especially prevalent in the Tropics (UNICEF-WHO JMP 2012).



Washbasins in India.
Image: Antony Robbins, Overseas Development Institute

Access to improved sanitation

Universal access to basic utilities such as water and sanitation is enshrined in international human rights instruments (UN Millennium Project 2005). History demonstrates that poor sanitation is one of the most significant contributors to the world's morbidity and mortality, and that improved sanitation provides considerable social, economic and environmental benefits.

Globally the provision of sanitation has been a key development goal since the 1970s, but progress toward universal coverage has been slow. Although an estimated 1.8 billion people worldwide gained access to improved sanitation facilities between 1990 and 2010, some 2.5 billion people (40% of the global population) do not have access to adequate sanitation, with many more lacking access to good quality sanitation.

A lack of infrastructure and poor maintenance of existing infrastructure are at the centre of the sanitation problem. Funding shortages, geographical and technological constraints and a lack of incentives for commercial involvement

mean that many governments and communities are unable to support the installation and maintenance of the necessary infrastructure (UNDP 2006). Sanitation is often given a low priority in government and donor budgets, and it is often those that are most in need of improved sanitation that are the least empowered to improve their circumstances or to afford such services. A health system focus on treating rather than preventing diseases has also been identified as a factor that can contribute to a lack of sanitation coverage (WaterAid 2011).

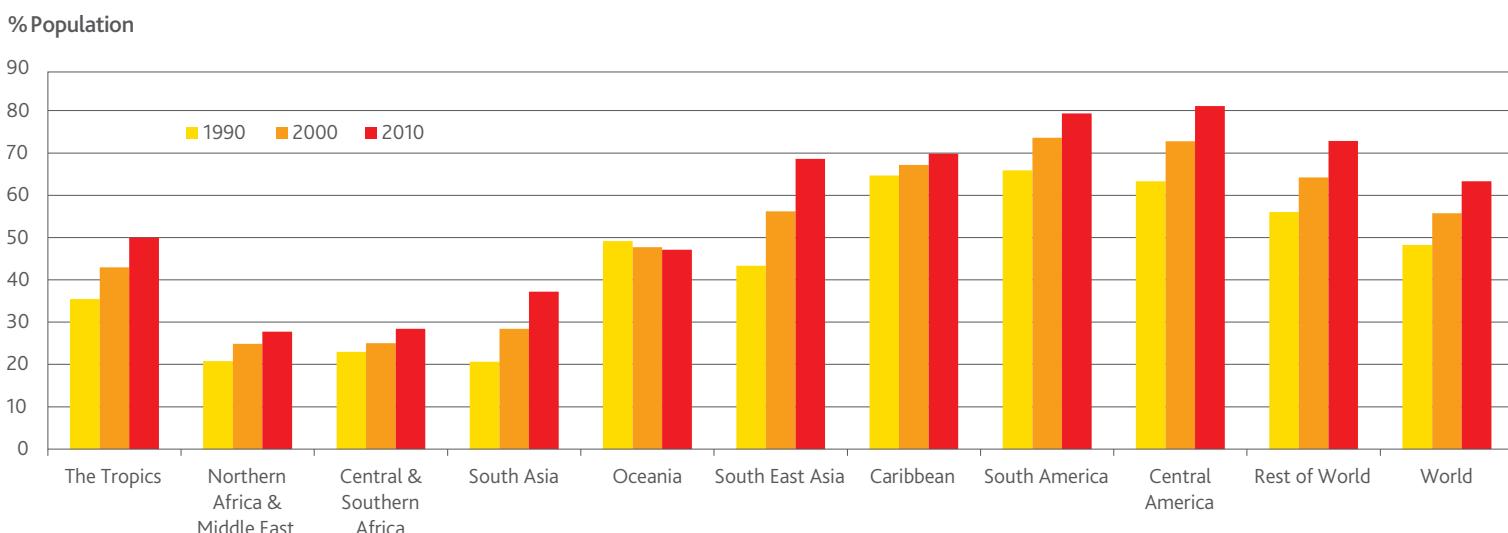
Poor sanitation can have many adverse impacts. Polluted water and living environments can lead to disease, premature death and child mortality. Poor sanitation can also decrease productivity, economic activity and lead to widened gender inequalities (World Bank 2008). These impacts highlight the need for sanitation having a higher priority on the international development agenda.

Trends

Differences in national interpretations of safe sanitation and variations in reporting methods are challenges to global analysis of sanitation standards. The United Nations Children's Fund and the World Health Organisations Joint Monitoring Program (JMP) have developed a proxy indicator – people using improved sanitation facilities – to measure sanitation progress (see Box 8.3.7). The JMP methodology has the potential to overestimate the number of people with access to improved sanitation sources, but it provides a reasonable measure for comparative purposes.

Globally, sanitation coverage increased from 48% in 1990 to 63% in 2010, with the number of people using improved sanitation facilities rising from 2.5 billion to 4.3 billion (see Figure 8.3.6). Sanitation coverage in the Tropics increased from 35% to 50%, while in the Rest of the World it increased 56% to 73%. That is, one-half of the population of the Tropics still

Figure 8.3.6 Improved sanitation source



Source: UNICEF-WHO JMP (2013), State of the Tropics project.

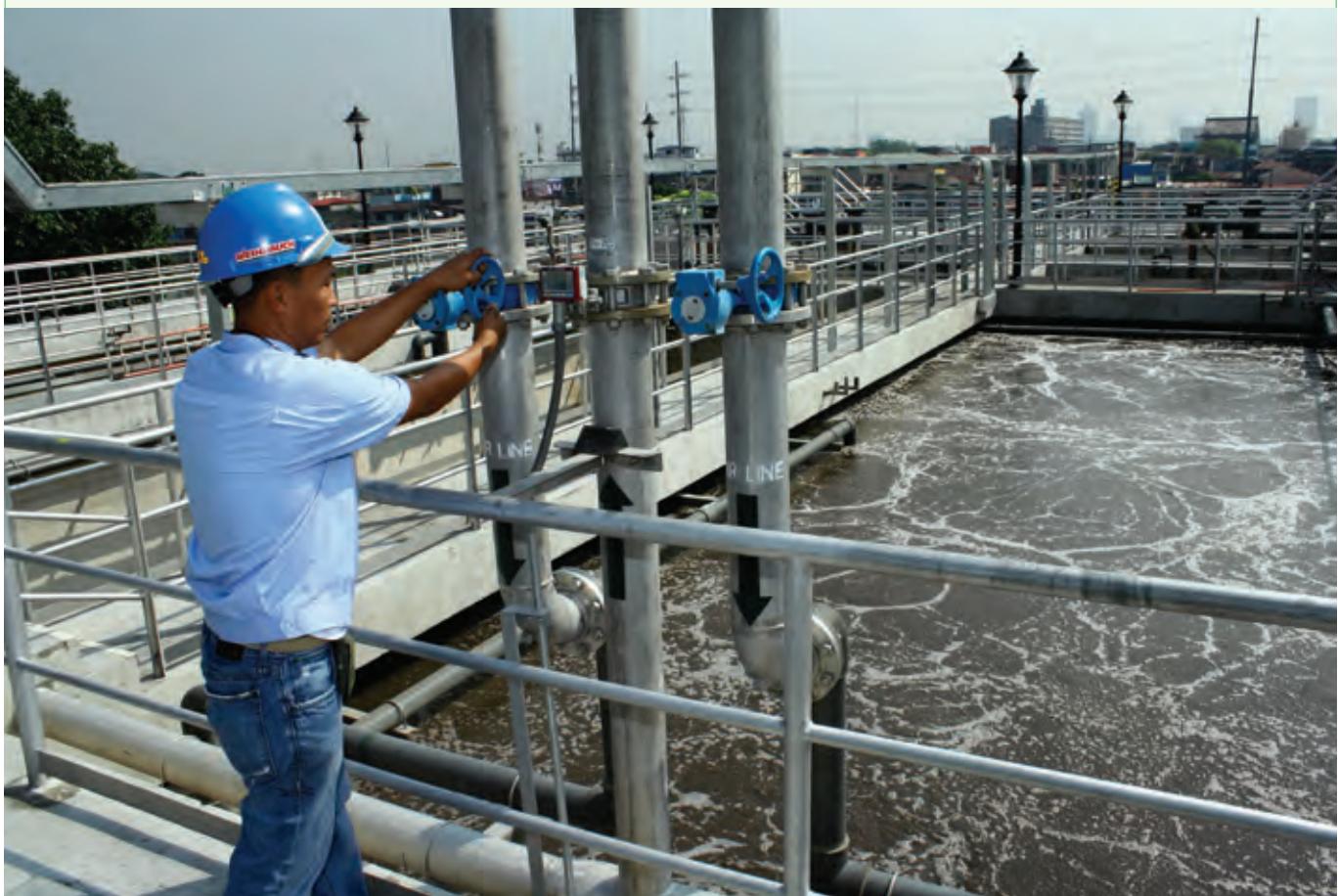
Box 8.3.7 UNICEF-WHO JMP measures of improved sanitation

The UNICEF WHO JMP sanitation data set estimates the population with access to improved sanitation technologies such as flush/ pour toilets and hygienic latrines. For the JMP an improved sanitation source is a facility which hygienically separates human excreta from human contact. The facility is required to isolate faeces from the individual and prevent flies and small animals from coming in contact with faeces (FIVAS 2011).

Improved sanitation sources include flush/ pour toilets piped to a sewer system, septic tank, pit latrine, ventilated improved pit latrines, pit latrines with a slab and composting toilets. Other forms of sanitation

(including no sanitation) are considered to be 'unimproved'. The JMP also classifies any sanitation facility that is shared or public in nature as being 'unimproved'.

A limitation of the JMP methodology is that it doesn't consider the quality of the improved sanitation source. For example, redefining sewerage-without-treatment as 'unimproved sanitation' is estimated to reduce the JMP-reported proportion of the global population with access to improved sanitation by 11 percentage points in 1990, and by 22 percentage points in 2010 (Baum et al. 2013).



Water treatment plant, Philippines. Image: Danilo Pinzon, World Bank.

does not have access to improved sanitation, compared with one-quarter of the population of the Rest of the World. The gap between the two regions with respect to the proportion of population using improved sanitation facilities has widened slightly since 1990. In the Rest of the World the number of people using improved sanitation increased by 1 billion to 2.8 billion, and in the Tropics there was a 0.7 billion increase to 1.4 billion.

Across the Tropics gains in access to improved sanitation have been variable. In 1990 improved sanitation coverage ranged from 21% in South Asia and Northern Africa & the Middle East to around 65% in the Caribbean, Central America and South America. At around 80%, coverage remains relatively high in Central America and South America, but progress in the Caribbean has been slow, affected by natural disasters, civil unrest and political instability in Haiti. In 2010 Central & Southern Africa and Northern Africa & the Middle East had the lowest proportions for improved sanitation coverage in the Tropics, at less than 30%. Civil unrest, poverty and rapid unplanned urban growth in many nations of these regions have affected the capacity to deliver sanitation infrastructure and solutions (SIWI 2005).

In the Tropics the greatest progress has been in South East Asia where the coverage rate increased from 43% in 1990 to 69% in 2010. This resulted in an additional 280 million people having use of improved sanitation facilities – the largest regional increase in the Tropics – followed by South Asia (an additional 170 million people) and Central & Southern Africa (100 million).

Oceania is the only region of the Tropics where coverage declined, from 49% in 1990 to 47% in 2010. This is driven by Papua New Guinea where, despite there being an additional 0.45 million people that now use improved sanitation facilities, infrastructure investment has not kept pace with population growth (ADB 2012). In Oceania the proportion of the population using improved sanitation declined in four of the 14 nations for which data are available.

Investment, socio-economic and cultural barriers

The means of improving sanitation are seemingly straightforward, but efforts to improve global access are complex and involve a range of financial, technical, political and cultural issues. Common barriers to increased access include inadequate investment in the necessary infrastructure, a lack of political will and a focus on conventional interventions without community involvement. On top of this, many programs do not assess the sustainability and success of interventions as input to future program development (Moe & Rheingans 2006).

Investments in sanitation infrastructure typically involve a long project cycle and high capital and operating costs. Poor economic and budget conditions in many nations with low coverage means that improving sanitation is often a lower order or neglected infrastructure issue, a situation not helped by the difficulty of quantifying the broad range of society-wide benefits that improved sanitation delivers¹⁵. High costs coupled with funding shortfalls mean that many developing nations rely on international aid to improve sanitation infrastructure.

Governments and international bodies typically combine water and sanitation into the same sector for development and administrative purposes, despite each having unique issues. As a development issue, water has historically received greater international attention and resourcing than sanitation, and this has led to sanitation being viewed as a less important add-on to water supply programs (Harvey 2008). In the decade to 2000, public investment in sanitation globally was just one-quarter that of water (World Bank 2008). In Africa it is estimated that sanitation made up just 12% of the water and sanitation sector investments between 1990 and 2000 (Graham 2011). These funding anomalies are widening, and in 2010 sanitation represented one-fifth of the total water, sanitation and hygiene sector expenditure in 2010 (WHO 2012b). Efforts to improve sanitation coverage have not been helped by the proportional decline in international aid

provided for water and sanitation compared with 20 years ago (Graham 2011).

Aside from the reported investment shortfalls in the sector, the allocation of limited financial resources to unsuitable interventions has compounded the challenge of extending improved sanitation services to unserved populations. Traditional sanitation projects focusing on the construction of centralised treatment systems have been somewhat ineffective in their ability to serve rural areas and rapidly growing, unplanned urban areas. Centralised approaches are frequently plagued by high capital costs, lack of proper operation and an overreliance on treatment technologies that are expensive and difficult to maintain (Montgomery & Elimelech 2007). Most people who do not have access to improved sanitation live on less than US\$2 per day, making the cost of conventional sanitation systems (US\$50-100 per month) not affordable (Rijsberman & Zwane 2012).

A lack of consideration for community culture, needs and priorities in decisions regarding location and type of sanitation facilities has ensured weak support from local populations for hardware interventions. This has led to a legacy of abandoned sanitation products and the use of sanitation facilities for a range of non-sanitation purposes including storage and animal shelters. In India, for example, a recent study showed that about 50% of toilets built by a large government program are not used for their intended purpose (Duncan et al 2010). Furthermore, in many areas of South Asia (Rajgire 2013) and Africa, the practice of open defecation is ritualised and bound in tradition and in certain circumstances it

¹⁵ Improved sanitation in developing nations has been estimated to yield about US\$9 worth of benefits for every US\$1 spent. The majority of the benefits accrue from time savings, but also from reduced direct and indirect health costs, higher returns to investments in education, protecting investments in improved water supply, safeguarding water resources and by boosting tourism revenues (UN Water 2008a). Other research suggests that for every US\$1 invested in achieving the MDG sanitation target and universal sanitation access in non-OECD nations would result in a global return of US\$91 and US\$11.2 respectively (Van Minh & Nguyen-Viet 2011). At the global level, the economic return on sanitation spending is estimated at US\$5.5 per US dollar invested (WHO 2012b).

Box 8.3.8 Community-Led Total Sanitation in Bangladesh

Even in the late 20th century open defecation was practised by up to one-third of the Bangladeshi population. With rapid population growth, and the lack of knowledge of the links between open defecation and disease transmission, the risk of sanitation-related infections and disease increased accordingly.

Early government programs to improve sanitation did little to address deeply entrenched attitudes, and tended to target households that were able to pay for such services. Latrines were seen as a luxury good rather than a necessity. But even in households with improved sanitation, people are still at greater risk of disease simply by being in such an environment.

Efforts to introduce low cost sanitation into Bangladesh have a long history. The Community-Led Total Sanitation approach (CLTS) – initially introduced to rural areas by non-government organisations (NGOs) in 2000 – has been the most effective.

At the core of CLTS is the recognition that provision of toilets does not guarantee their use or improved sanitation and hygiene practises.

As such, CLTS is a communication-based approach that focuses on behavioural change by raising awareness of the link between open defecation and disease. The process requires whole of community involvement, with an emphasis on highlighting the collective benefits of eliminating open defecation, rather than focusing on individual behaviour or toilet construction.

Early success with the CLTS encouraged political support and national and state governments expanded efforts to improve household sanitary practices, with a goal to achieve nationwide sanitation coverage and stop open defecation in rural areas by 2010. Sanitation coverage increased from 38% in 1990 to 54% in 2010, and open defecation rates fell from 32% to 5%, driven by major improvements in rural areas. The CLTS is believed to be a major contributor to this outcome.

There are also positive signs that reducing open defecation is delivering considerable health benefits to rural communities. A 2008 study assessing the impact of CLTS found that it reduced diarrhoea cases by 30% for men and 50% for women, and halved the length of illness (Howes et al. 2009).



New latrines in Bangladesh. Image: Water.org.

is believed that these cultural values and beliefs have led to a resistance in the use of toilets (WaterAid 2009).

Aside from investment in infrastructure, a key factor to improving sanitation outcomes is providing education and training in good hygiene practices and improving awareness of the benefits of good sanitation practices, especially in communities that have not previously had sanitation.

Past shortfalls in infrastructure provision has led to a major shift in policy orientation towards demand-led approaches to improving sanitation. These are aimed at motivating people to improve their own sanitation and accelerate sanitation coverage in both rural and urban settings. One of these approaches is Community-Led Total Sanitation (CLTS) which was first developed in the rural communities of Bangladesh in 2000. CLTS has had considerable success in improving sanitation outcomes, and is being implemented in an increasing number of Tropical nations in Asia, Africa and Latin America (see Box 8.3.8) (Duncan et al. 2010).

The links between sanitation, water pollution and health

For developed nations access to onsite flush toilet facilities and the removal of waste via a sewer or septic tank at the push of a button is taken for granted. Yet for more than 50% of the people that live in the Tropics, such facilities are unavailable, and the separation of water and excrement is a formidable public health issue. In urban slums and rural communities the absence of quality sanitation facilities frequently means human waste is disposed in fields, on streets and in drains, creating an immediate local hazard and ideal conditions for disease vectors. In some regions human excreta contaminates surface and ground water or is discharged untreated into rivers and water systems, causing serious pollution and endangering the health of downstream users, plant life and aquatic resources (UN Water 2008b).

The anticipated health benefits of improved water supply have been severely limited by poor progress in the management of human excreta, one of the primary pathogenic sources of water contamination (UN Water 2008b). Diseases associated with poor sanitation account for about 10% of the global burden of disease, with diarrhoeal diseases – generally due to faecal-oral transmission of viral and bacterial pathogens – the most prevalent, causing up to 2.5 million deaths annually, mostly children in developing nations (Duncan et al. 2010). In 2008 diarrhoea was the leading cause of death among children aged under five years in sub-Saharan Africa (accounting for 19% of all deaths in this age group). It is estimated that improved sanitation could reduce rates of diarrhoeal diseases by up to 37% (Duncan et al. 2010).

The practice of open defecation – the last recourse for those without any form of sanitation – poses one of the more serious pollutant threats to ground water resources and agricultural produce, and is a major contributing factor to diseases such as diarrhoea, worm infestations, hepatitis, cholera and typhoid. Despite the proportion of the world's population practising open defecation declining from 24% in 1990 to 15% in 2010, more than one billion people still participate in this unhygienic practice, with 90% of these living in rural areas, and around two-thirds of them living in the Tropics. In the Tropics rates of open defecation are highest in South Asia (46%), followed by Northern Africa & the Middle East (42%) and Central & Southern Africa (24%), with the incidence reportedly greatest in rural areas. In other tropical regions the problem is less acute, with rates ranging from 3% in Central America to 12% in South East Asia.

Although the scale of sanitation needs in rural areas is large, public health risks in urban slums where inhabitants live in cramped and squalid living conditions are considered more acute. The illegal status of many of these settlements means they are not recognised by the authorities responsible for providing sanitation and are excluded from town planning. Even in slum areas where the use of improved sanitation facilities

such as pit latrines is common, the risk of faecal-oral disease remains high. At any given time it is estimated that close to one-half of the urban populations of Africa, Asia and Latin America have a disease associated with poor sanitation, hygiene and water (Duncan et al. 2010).

Looking forward

Currently, more people have access to a mobile phone than a clean, functioning toilet. Future progress in the sector requires both adequate investment and collaborative action across developing nation and donor governments, civil society, multilateral agencies and the private sector. Progress has been made in the formation of the World Toilet Organisation through the United Nations which aims to provide sanitation for all. World Toilet Day (19 November) became an official UN day in 2013 based on Singapore's first resolution to the UN.

Nations that have established clear institutional responsibility and specific budget guidelines for sanitation quite distinct from the water sector have had greater sanitation outcomes. Top-down centralised supply led infrastructure solutions have historically dominated the sanitation landscape with limited effectiveness. Decentralised demand led strategies such as the Community-led Total Sanitation programs have met with considerable success in a number of tropical nations.

However in order for these bottom-up approaches to have a greater impact on sanitation coverage, future programs will need to be implemented on a much larger scale than has occurred to date.

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INTERNET
ZANZIBAR





Chapter 8.4

Governance | Information technology and communications

Kalen Sing, a fisherman from Vanuatu.
Tom Perry, World Bank.

Summary of communication indicators

Indicator	Tropics	Central & Southern Africa	Northern Africa & Middle East	South Asia	South East Asia	Caribbean	Central America	South America	Oceania	Rest of the World	World
Mobile phone subscriptions 1993-2010*	0.1 - 68	0 - 42	0 - 50	0 - 61	0.2 - 85	0.4 - 58	0.3 - 92	0.2 - 101	1 - 51	1 - 83	1 - 77
Fixed broadband subscriptions 2000-2010*	0.03 - 2.4	0.0 - 0.07	0.0 - 0.56	0.0 - 0.86	0.08 - 4.1	0.0 - 3.3	0.01 - 7.4	0.04 - 5.7	0.3 - 6.3	0.4 - 11.3	0.3 - 7.6
Internet users 1993-2010**	0.01 - 17	0 - 10	0 - 10	0 - 7	0.02 - 23	0 - 23	0.02 - 26	0.02 - 38	0.51 - 21	0.3 - 38	0.2 - 29

* Represents subscriptions as a percentage of total population. ** Represents users as a percentage of total population.

Is it getting better?

Mobile phone subscriptions - Over the past decade the mobile phone has emerged as one of the fastest growing consumer technologies ever introduced. In the Tropics mobile telephony has become the dominant means of communication and the principal gateway to increased information communication and technology (ICT) access and use, with penetration rates reaching 68% in 2010 up from 0.1% in 1993. The rapid growth of mobile phones in the region is partly due to low initial access. In absolute terms the Tropics remains well behind the Rest of the World, with subscriber numbers still only around a third of the global total. Despite a significant increase in diffusion across all Tropical regions considerable inter regional disparity persists, with rural populations experiencing the lowest rates of mobile connectivity.

Market liberalisation in combination with technological and commercial innovation have generated more affordable infrastructure, cheaper handsets, competitive markets and business models oriented to the needs of poorer population segments living in the Tropics thereby enabling greater mobile take up.

Internet users - Internet diffusion in the Tropics has grown quickly in terms of both users and penetration, though access is considerably less widespread than mobile communications. Growth rates of 30% per annum in the preceding decade (twice that in the Rest of the World) enabled the number of Internet users in the Tropics to reach 471 million in 2010 and achieve a penetration rate of 16.5%. Despite these positive developments Internet use in the Tropics is progressing slowly in some regions and overall diffusion is considerably lower here than in

the Rest of the World. As with fixed broadband, Internet penetration remains lowest in Central & Southern Africa, Northern Africa & the Middle East and South Asia. Poor telecommunications infrastructure, market control by incumbent telecommunications operators, low rates of personal computer ownership, cost of access, low literacy levels and lack of relevant content in local languages are some of the factors which make the Internet a more difficult ICT to disseminate in these regions.

In the absence of fixed broadband infrastructure, access to the Internet via public access points such as Internet cafes and more recently through mobile broadband networks has contributed to increased Internet connectivity within many nations in the Tropics.

Fixed broadband internet subscriptions - In the Tropics fixed broadband subscriptions increased one hundred fold in the 10 years to 2010. Despite progress, this technology remains in its infancy, with penetration sitting at just 2.4% of regional population in 2010. The Rest of the World continues to dominate global subscription numbers and the gap in terms of penetration with the Tropics has widened since 2000. Diffusion in the Tropics is now one fifth of that in the Rest of the World and variations between the different Tropical regions are also significant. Subscriptions as a proportion of population were less than 1% in Central & Southern Africa, Northern Africa & the Middle East and South Asia in 2010. Infrastructural and market differences have created price conditions that are less ideal for the adoption of broadband by consumers in these regions.

The rapid growth of information technology in the late 20th and early 21st century has facilitated social and economic development and global coordination of business, trade, governance and security on an unprecedented scale. Information Communication Technology (ICT) refers to any technology that enables the communication and electronic capture, processing and transmission of information. The concept encompasses older technologies such as radio, television and fixed line telephony as well as the more recent innovations including personal computers, mobile phones, broadband networks and the Internet. The potential of the new ICTs lies in their capacity to instantaneously connect vast networks of individuals, organisations and governments across all corners of the world. ICTs have become key enablers of globalisation, facilitating world-wide flows of information, capital, ideas and products.

Over the past decade nations in the Tropics have experienced rapid but uneven growth in ICT access and use. The unprecedented expansion of mobile technologies, driven by private sector investment and supported by reforms to promote competition, has improved affordability and enabled the expansion of phone services to previously underserved populations. Beyond mobile telephony, large disparities exist in Internet access, high speed broadband connectivity, and in the diffusion and use of ICT in services, business and government.

The benefits that information and communication technology can bring to societies and their inhabitants arise from societal improvements based on economic growth and other developments, such as enhancements in education, business facilitation, access to markets and government processes. At the individual level, ICT enables people to communicate more easily, undertake tasks more efficiently and access income generating opportunities more readily.

By increasing productivity and therefore economic growth in developing nations, ICT

has a formidable role to play in reducing poverty and improving living conditions and opportunities for the poor.

Headline indicator

Mobile phone subscriptions: Mobile phone subscriptions per capita are an indicator of mobile phone diffusion within a nation. Frequently the first gateway to ICT in developing nations, mobile telephony has enabled developing nations to overcome infrastructure barriers and deliver communication networks to previously unconnected populations. The mobile phone industry has emerged as an enabler of substantial economic and social development, helping to lift citizens out of poverty and extending social and digital inclusion. Mobile broadband has the potential to expand the transformative capabilities of mobile technologies through its capacity to bring Internet to consumers in developing nations.

Supplementary indicators

Internet users: The Internet, the global system of interconnected computer networks, is a mechanism for information dissemination and a medium for interaction between individuals, businesses and governments across all types of traditional boundaries. Information and content availability over the Internet is seen as a critical enabler to greater inclusion, empowerment and human development for its users.

Fixed broadband internet subscriptions: Fixed broadband facilitates access to the highest quality Internet services via a variety of high speed technologies including digital subscriber line (DSL), cable modems and fibre optic cable. Apart from high speed, the ever present, always connected and secure characteristics offered by broadband technologies allow individuals access to a greater range of services and a richer Internet experience. Broadband generates substantial benefits to the productivity, education and economic development of society in general.

Although increasingly commonplace and affordable in many areas of the world, fixed

broadband services remain either unavailable or prohibitively expensive in many developing nations. Low penetration levels constitute a significant barrier to a nation's meaningful entry into the global information economy, economic competitiveness and macroeconomic growth. Nonetheless, the rapid roll out of mobile broadband infrastructure and services is contributing to significantly stronger take up of broadband using mobile technologies.

Links to other dimensions

Infrastructure; Economic output; Poverty; Gender equality; Work.

Mobile phone subscriptions

Telecommunication plays a vital role in modern society and is instrumental to the organisation and operation of the global economy. Since the 1990s rapid technological change, globalisation and significant increases in the information intensity of economic activity have made information and communication technology (ICT) critical to a nation's competitiveness, growth and social development (World Bank 2006).

Over the past 30 years ICT access in most nations has increased considerably, with much of the recent growth centred on mobile (or cell) telephony. In 2002 the number of mobile phone subscriptions reached 1 billion, surpassing the number of fixed line connections for the first time (Zhen-Wei 2009). In comparison, it took over a century for the world to accumulate the first billion fixed telephone lines. By 2010, mobile phone subscriptions had increased to 5.3 billion, representing 77% of the world's population.

In the developed world mobile phone subscriptions increased incrementally as the technology complemented or replaced existing services. In developing nations however, mobile technology has often provided households with their first access to telecommunications, and take-up rates have been high. The rapid spread of mobile phone technologies in developing nations has also been enhanced by a number of other factors, such as technological improvements that have lowered costs relative to fixed wire networks, falling handset prices, the introduction of prepaid subscriptions, rising incomes and strong competition among service providers (World Bank 2012a).

In many societies mobile technology is so entrenched that the story is no longer about the phone itself, but rather how it is used, and the content and applications to which the phones provide access. The mobile phone also offers a range of economic, political and social capabilities, and some commentators suggest that it is the single most transformative technology for development (Bloomberg Business Week 2007). Mobile phones allow users quick and efficient access to health, education, employment, public safety, transportation and legal services. Many core economic activities are

increasingly conducted over mobile networks as new technologies and innovations change business and service delivery models. This is bringing new services and opportunities to many regions of the world, and is especially apparent in the banking and retail industries.

The expansion of mobile networks has been supported by the deregulation of state controlled monopolies and massive private sector investment in infrastructure and ICT in general. Especially in developing nations, this liberalisation has facilitated access to foreign capital and technology, which has encouraged competition and delivered modern and affordable services (World Bank 2006). Between 1990 and 2010 some 329 projects in the mobile telecommunications sector in developing regions attracted \$441 billion in private sector investment, much of it from foreign multinational corporations (World Bank 2012a).

Trends

The mobile phone was introduced more than 30 years ago and is now the most widely used communication technology in the world. The traditional measure of mobile telephony penetration is the number of mobile phone subscriptions as a percentage of the population and, despite its imperfections it is used in the analysis here.

Between 1993 and 2010 the number of global mobile phone subscriptions increased from 33.6 million to 5.3 billion (33% per annum), with the result that the penetration rate increased from less than 1% in 1993 to 76.8% in 2010.

The Tropics has followed a similar pattern to the Rest of the World with respect to mobile phone take up, albeit with a lag (see Figure 8.4.1). Mobile phone use was initially concentrated in industrialised nations, most of which are in the Rest of the World, where subscription rates increased from 0.9% of the population in 1993 to 83.3% in 2010. The mobile penetration rate has consistently been lower in the Tropics (at 0.1% in 1993 and rising to 67.7% in 2010) but the gap has

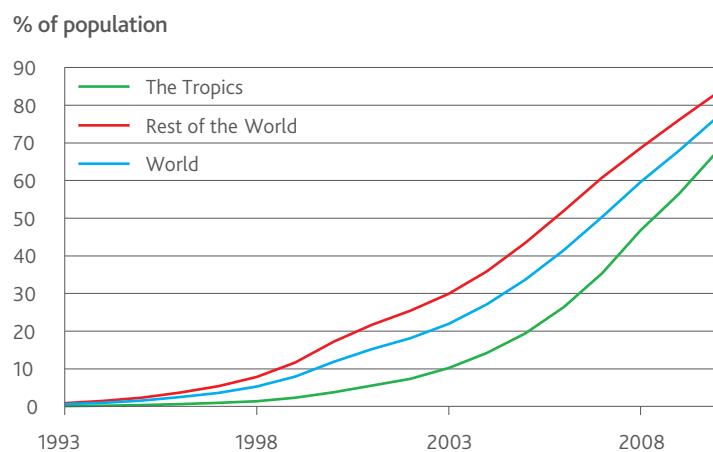
been narrowing over time. In 1993 the penetration rate in the Tropics was only around 10% that of the Rest of the World, increasing to more than 80% in 2010. Nonetheless, the gap between the Tropics and Rest of the World, at 15.6 percentage points in 2010, is still significant, but a considerable improvement from the 25.6 percentage point gap in 2006. At just 1.2% in 2010, the tropical nation of Burma/Myanmar had the lowest mobile phone subscription rate in the world (1.2%), followed by North Korea at 1.8%.

Mobile phone subscriptions in the Tropics increased from 2.45 million in 1993 to 1.9 billion in 2010, compared with an increase from 31.1 million to 3.3 billion in the Rest of the World (see Table 8.4.1).

For developed nations, greater access to capital and skilled labour combined with generally more stable political and industry networks assisted with the initial transition to mobile technologies. As many of these nations are in the Rest of the World, this goes some way to explaining variations compared with the Tropics. The difference between the Tropics and Rest of the World has also been compounded by the initial perception by some phone companies that mobile telecommunications was a non-essential service with limited growth prospects in low and, to a lesser extent, middle-income nations (Andjelkovic 2010). This contributed to delays in many companies entering these markets and the gap that still exists between developed and developing nations.

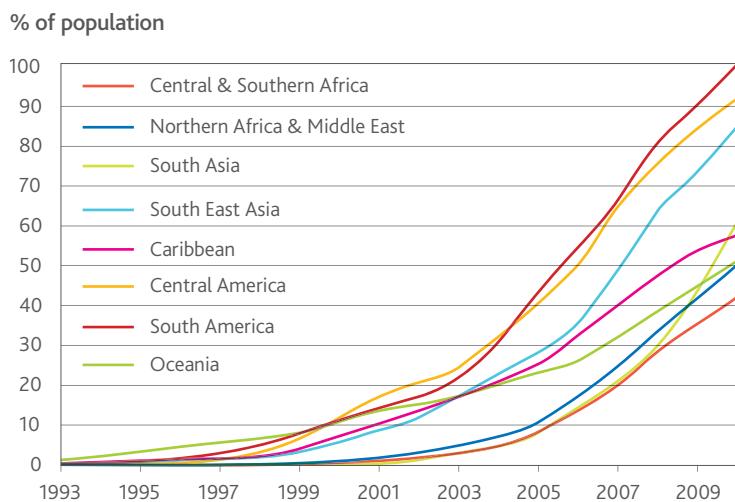
All tropical regions report large increases in mobile phone subscriptions since 1993 but there is considerable variation between regions. From subscription rates ranging from 0% to 1.2% in 1993, they now range from around 40% in Central & Southern Africa to over 100% in South America (see Figure 8.4.2). Market liberalisation in many Latin American nations saw the region attract a large share of foreign investment in telecommunications in the 1990s and early 2000s which, combined with competition, were key drivers for high take-up rates in South America and Central America. One of the largest transactions was the 1998 privatisation of Telebras, Brazil's state owned monopoly telephone (World Bank

Figure 8.4.1 Mobile phone subscriptions



Source: ITU (2013), State of the Tropics project.

Figure 8.4.2 Mobile phone subscriptions – the Tropics



Source: ITU (2013), State of the Tropics project.

2006). Eight separate mobile companies emerged from the privatisation, and mobile subscriptions increased from 6 million in 1998 to 174 million in 2010, an average growth rate of 32% per annum.

At 42%, Central & Southern Africa has the lowest mobile subscription rate in the Tropics. While mobile coverage in this region followed a similar pattern to South Asia until 2005 (both regions had subscription rates around 0.5% in 2000 and 8% by 2005), by 2010 Central & Southern Africa lagged South Asia by almost 20 percentage points. Stronger growth in South Asia was influenced by low tariff rates coupled with a significant increase in household incomes in India around the same time (Singh 2006). In addition, a large proportion of Central & Southern Africa's population is under the age of 15, limiting the size of the mobile phone market in this region (GSMA 2012). Interestingly, up until 2000 the pattern of growth in Central & Southern Africa was confined to a small sample of nations, but by 2010 it was widespread, with almost half of the nations in this region reporting subscription rates higher than 50%.

In absolute numbers South East Asia has consistently been the largest market for mobile telephones in the Tropics, with subscriber numbers increasing from 1.5 million in 1993 to almost 650 million in 2010. Indonesia, another significant beneficiary of foreign investment, has accounted for more than one-third of the increase.

In the Tropics South Asia has also had rapid growth in the number of mobile phone subscribers, increasing from 15,000 in 1993 to 474 million in 2010. India has driven this growth, with the penetration rate reaching 61% in 2010, up from zero in 1993. The emergence in India of a competitive and innovative private sector contributed to the development of cost-effective business models which reflected local needs. These firms have been very successful in attracting new customers (see Box 8.4.1). Rapid progress in India masks much slower development in other nations in the South Asia region.

Affordability has been a major factor influencing the rapid penetration of mobile technologies in

Table 8.4.1 Mobile phone subscription trends

	1993		2000		2006		2010		1993 to 2010		
	%	Million	%	Million	%	Million	%	Million	PPT* change	Million	Av. An. Growth
Tropics	0.1	2.45	3.7	91	26.4	706	67.7	1,932	67.7	1,932	45.5%
Central & Southern Africa	0.0	0.02	0.5	3	13.5	84	42.2	288	42.2	288	71.6%
Northern Africa & Middle East	0.0	0.01	0.9	1	16.8	23	50.2	76	50.2	76	62.9%
South Asia	0.0	0.01	0.4	3	14.7	108	61.0	474	61.0	474	81.3%
South East Asia	0.2	1.48	5.5	37	35.4	259	85.0	646	84.8	645	41.1%
Caribbean	0.4	0.12	7.3	3	32.6	13	57.7	23	57.3	23	34.7%
Central America	0.3	0.31	11.9	14	50.2	62	92.0	120	91.6	120	39.8%
South America	0.2	0.38	11.5	30	54.7	155	100.6	299	100.4	299	45.9%
Oceania	1.2	0.11	10.9	1	26.1	3	51.2	6	50.0	6	24.6%
Rest of the World	0.9	31.1	17.2	629	52.0	2,010	83.3	3,337	82.4	3,337	30.4%
World	0.6	33.6	11.8	720	41.5	2,716	76.8	5,269	76.2	5,269	32.9%

Source: ITU (2013), State of the Tropics project.

* Percentage point.

most tropical regions. Access to prepaid services and the development of cheaper handsets have reduced the cost of mobile services, making them more accessible to people in developing nations, and particularly in the cash-based societies of Central & Southern Africa and South Asia (The Economist 2009).

Direct and indirect benefits

The mobile phone industry has become a significant sector in many economies, with operators generating an estimated US\$848 billion in revenue in 2011 (World Bank 2012a), as well as contributing to and facilitating economic growth more broadly. Research suggests there is a correlation between mobile phones and economic

growth, with a study of 120 nations indicating that an additional ten mobile phones per 100 people is associated with an increase in economic growth of 0.8 percentage points in developing nations, and 0.6 percentage points in developed nations (Zhen-Wei 2009).

The mechanisms by which mobile telephony can impact economic activity vary considerably. In developing regions where the movement of people, goods and information may be constrained by poor infrastructure, the introduction of cheap mobile communications has become a substitute for transport. Mobile phones also allow for more efficient dissemination of information and can improve the functioning of firms and markets by reducing transaction costs, and have the capacity to improve productivity in both the public and private

sectors. As these issues tend to be more acute in developing economies, the economic benefits from improved telecommunications access are more pronounced in developing nations.

Notwithstanding significant indirect impacts, mobile telephony is an increasingly significant industry in its own right. In Vietnam mobile network operator revenues as a percentage of GDP increased from 3.2% in 2008 to 5.8% in 2010, driven by the mobile phone penetration rate increasing from 87% to 127% (GSMA 2011), while in sub-Saharan Africa the mobile sector accounted for 4.4% of regional GDP in 2011. In emerging markets this has included the development of 'tech hubs' such as Nokia's dedicated research centre in Nairobi, which is focussed on developing regionally specific products (GSMA 2012).

Box 8.4.1 Mobile phones in India

The spread of mobile phones in the developing world has been accompanied by the rise of local operators, many of which now rival or exceed international competitors. A factor contributing to this is the development of new business models and industry structures by local service providers that enable them to make a profit from serving low-spending customers – customers that many Western firms would not pursue. An example of this is the initial focus by Western firms on post-paid plans, which are more onerous and costly to operate, and which severely limit the potential market size and demand.

In the developing world Indian service providers have been at the forefront of this innovation process, and their models and products have been adopted by operators in other nations. A key to their success has been a focus on affordability.

Outsourcing and infrastructure sharing are at the centre of the 'Indian model'. The outsourcing of functions such as information technology operations, mobile network operations and customer care contributed to efficiencies in managing and mitigating risks associated with a rapidly growing subscriber base, and allowed operators to concentrate on revenue-generating activities such as innovation, marketing and strategy. The sharing of infrastructure such as towers, network antennae and generators has also been a key feature of the Indian model.

This is not a new strategy, but the extent of voluntary, market-led sharing to reduce costs is significantly higher in India.

Lifetime prepaid schemes (where customers pay a one-off fee and can receive incoming calls indefinitely); widespread use of paperless top-ups (reducing the cost of distributing top-up vouchers), and energy reduction measures (for instance, where equipment is automatically turned off at night or when traffic volumes fall), are examples of innovations used by mobile operators to lower costs and improve affordability.

Despite cheap call charges and relatively low average revenues per user, mobile operators in India reported operating margins comparable with leading international operators, at around 40% in 2008 (The Economist 2009). However, after years of rapid growth subscription rates have started to moderate as businesses have had to increase tariffs to remain viable, with impacts on those new and existing consumers that are particularly price sensitive. This is more likely to be the case in rural areas, where infrastructure and subscription rates are relatively low. In 2011 the mobile phone subscription rate in rural India was 11%, compared with 156% in urban areas (PwC 2011).



Image: M DeFreese, CIMMYT.

As technology has improved, mobile phones have also evolved from being simple communications tools to multi-purpose devices offering a range of voice and data services. Combined with rapid service innovation, this means mobile phones have become truly transformative devices. Today mobile phones provide the platform for a variety of health care, banking and other services, as well as creating a range of previously unavailable employment opportunities, especially in developing nations.

For example, exclusion from the formal financial system is recognised as a barrier to poverty alleviation and economic growth, and can also exacerbate inequality between the rich and the poor (World Bank 2012a). Prior to mobile phones many households in developing nations, and especially in rural areas, did not have access to formal banking services. Since mobile banking services first emerged in the developing world more than a decade ago, it has brought millions of people into the financial system for the first time. At least 110 mobile money systems had been deployed by 2012 providing financial services to 40 million users, many of which are in sub-Saharan Africa (World Bank 2012a).

Rapid growth in the mobile phone industry has also created significant direct and indirect employment opportunities. In 2011, the mobile phone industry in sub-Saharan Africa created more than 3.5 million jobs across both the formal and informal sectors (GSMA 2012), while in India the sector employs around 2.8 million people directly, and another seven million people indirectly (PwC 2011).

Entrepreneurial ventures based on mobile technology include short-term renting of phones, which has significantly improved the connectivity of communities – and especially rural communities. First introduced in Bangladesh, this style of business has now successfully expanded into many tropical African nations. For entrepreneurs and business people the mobile phone has also become essential for accessing market and price information, customer liaison, coordinating logistics, and financial transactions, and is making it easier to operate in locations where it would otherwise be impossible.

In the public sphere mobile technology is significantly expanding the capacity of governments to deliver services. Governments in various stages of economic development have adopted the concept of mobile government (m-Government) – an extension of the e-Government concept – focused on using mobile technologies to improve client access, service delivery and productivity. Already m-Government is being used to cost-effectively deliver SMS and Internet-based information and interactive services in areas such as health, education, employment, transportation, finance and public safety (OECD & ITU 2011). Research also suggests that using online or mobile technologies to engage the public in decision making can have a positive impact on trust and perceptions of government responsiveness.

Although still in its infancy, as mobile technology reaches more people, m-Government has great potential to benefit unserved and under-served populations. Many of these people will live in rural areas and, combined with improved business and employment-related opportunities, mobile technologies can improve wellbeing through economic and social development.

Regulatory environment and spectrum management

There is growing consensus that inefficient regulatory practices negatively impact the introduction and growth of mobile technologies and services, and have contributed to higher prices and artificial scarcity in a number of nations (ITU 2007). For example, low-income African nations with more competitive markets have 31% higher rates of mobile penetration than those with uncompetitive markets (World Bank 2012b). As a consequence, more and more nations are introducing reforms to improve regulatory practices, including measures such as competitive spectrum auctions.

Radio spectrum¹⁷ is the airwaves over which mobile voice and data travel, and is critical for all forms of wireless communication. At the global level, spectrum is managed by the International

Telecommunication Union which, amongst other things, aims to prevent interference between competing services, such as mobile phones, radio and television broadcasting and satellite communication systems. Beyond this spectrum allocation, individual nations are responsible for spectrum management within their own borders (for example, decisions regarding the quantity of spectrum to be released to individual operators).

Spectrum is a finite resource, and shortages can often coexist with under-utilisation as a result of inefficient use. Over the past two decades there has been a move away from the prescriptive 'command and control' approach (typically a legacy of earlier government practices) to spectrum management and more market-orientated systems. A number of controlling Government practices have been abolished or changed to improve the efficient use of spectrum. These practices include the following: retention of large underutilised parcels for public sector entities like the military; the assignment of spectrum on an exclusive or national basis regardless of demand, neglecting to reallocate spectrum left vacant by changing technology; and spectrum hoarding.

More efficient spectrum management will become increasingly important as users shift from voice and SMS services to more data-intensive web services, which also leads to significant volatility in spectrum loads. Globally, mobile data traffic is expected to increase substantially in the next few years. In the Tropics, nations such as India, Brazil and China have, on average, more than doubled data usage every year since the technology was introduced (GSMA 2012).

Mobile networks in sub-Saharan Africa anticipate a 25-fold increase in internet traffic in the four years to 2016 as smart phone technologies become increasingly available (GSMA 2012). Nations in this region have among the lowest spectrum allocations in the world, which will need to be addressed if demand is to be accommodated without significant increases in user costs and/or lower service quality in the form of poor network access, congestion and lower speeds – each of which is likely to inhibit the full transformative

Box 8.4.2 Guatemala

Prior to 1996 radio spectrum in Guatemala was owned by the government, which issued prescriptive and revocable licenses for its use. Radio spectrum management was highly regulated and inefficient by international standards. Frequencies above 800 megahertz (MHz) were controlled by a state-owned company, with frequencies below 800MHz regulated by an agency (Elbittar 2010). Additionally, exclusive mobile telephony rights had been awarded to one private company. Mobile phone penetration rates were low at this stage, but similar to many other middle income nations.

Reform and deregulation of Guatemala's telecommunication sector commenced in 1996 when mobile telephony was in its infancy. While state ownership of the spectrum was maintained, the reforms gave companies access to a greater range of spectrum, allowed licensees to lease, sell, subdivide or consolidate their spectrum titles, created an independent regulator, and generally encouraged new entrants and competition.

The impact of these changes was immediate, and in the five years to 2001 the number of fixed and mobile telephone connections increased at an average rate of 38% per annum, compared with 9% per annum between 1985 and

1995 (ITU 2003). Guatemala's three leading mobile phone providers entered the market between 2003 and 2004, and their scale and innovation contributed to competition, improved affordability and increased connections, with subscription rates increasing from 13% in 2002 to 140% in 2011.

Mexico provides a counterpoint to Guatemala. Since 2000 growth in mobile subscription rates in Mexico has been considerably lower than other nations in Central America, including Guatemala. In 2000 Mexico had the highest penetration rate in Central America at 14%, but by 2011 it had slipped to sixth highest. Although Mexico has a liberal regulatory environment, the impacts of asymmetric concessional arrangements granted to one operator when the mobile market was emerging – and which have subsequently been wound back – has resulted in it retaining significant market power (Prieto 2011). Combined with foreign investment restrictions, this has contributed to a situation where the telecommunications sector is dominated by one operator which has around 70% market share. This market power, combined with other barriers to entry, has contributed to relatively weak competition, high prices when connecting across networks, low rates of innovation and slow growth in subscription rates.

potential of mobile technologies. Although these issues may be more acute in developing regions, spectrum supply constraints are an issue that all nations are likely to face at some stage.

There are always exceptions though, and spectrum authorities in a number of developing nations have emerged as leaders in developing regulatory environments that support competition and innovation. For example, in Guatemala spectrum-related reforms have improved the efficiency and affordability of mobile technologies (see Box 8.4.2).

Looking forward

Looking forward, mobile access, capacity and affordability should continue to improve, and mobile technologies represent a powerful platform for the development of commercial and social applications. The main challenges facing the continued uptake and utilisation of mobile technologies in many developing and tropical nations will be creating the regulatory environment that encourages investment and competition, and ensuring that spectrum management is adequate to cater for the rapid uptake of data-intensive smart phone technologies.

While mobile take-up rates are increasing rapidly (there were 28 mobile connections for each fixed line subscription in sub-Saharan Africa in 2010), in some nations and sub-populations – especially in the rural areas – take-up is relatively low, and often reflects the extent of limited infrastructure development into these areas. Increased investment in network coverage into rural and remote areas will encourage greater connectivity and diffusion of other technologies, and will act to narrow the digital divide that exists both within and between nations (World Bank 2008).



Mobile phone tower. Image: R512.

¹⁷ Radio spectrum refers to electromagnetic radiation of different wavelengths and frequencies used for fixed and mobile communication, broadcasting, radio navigation and fixed and mobile satellite services. The optimal bandwidth for mobile communications is between 400 megahertz to 5 gigahertz.

Internet users

The Internet is one of the most important technological developments in recent history. With origins dating back four decades it was only through the development of the World Wide Web in the early 1990s that the Internet emerged as a commercial undertaking, revolutionising the way people communicate with one another and obtain information.

Today the Internet is a widespread information infrastructure providing near instant communication on a global scale via email, instant messaging, video conferencing and social networking. Its influence reaches not only to the technical and social fields of computer communications but throughout society there is increasing use of online tools for electronic commerce, information acquisition and to access public services.

In 2010 there were 2 billion people connected to the Internet worldwide. Although usage has diffused rapidly there are inequalities, both within and across regions. For example, penetration rates in developed nations average around 75%, while in developing nations it is just 24% (UNCTAD 2011). In developing nations usage is concentrated in urban areas, with limited connectivity into rural areas. This disparity in access underlies the digital divide, which is increasingly significant as a global development issue given that Internet access has become important for economic and productivity growth, and for the delivery of government and business services.

Major barriers to Internet access include: limited or underdeveloped telecommunications infrastructure; low household incomes and literacy levels; cost of access; low rates of personal computer ownership; a lack of computer literacy; and a limited supply of web content in local languages adapted to local needs. The impact of these barriers differs with the level of economic and social development of a nation.

In the past decade fixed broadband technologies have emerged as the next step in Internet development (see Box 8.4.3). This has occurred

as relatively static content is increasingly replaced by graphically rich multimedia which requires greater bandwidth, high speed transmissions and high quality Internet connectivity. Fixed broadband requires major investment in infrastructure, and its availability is largely confined to developed nations at present.

More recently, next-generation mobile cellular technologies and the wider adoption of sophisticated broadband-enabled mobile devices have raised the possibility of more rapid and cost-effective infrastructure development, with potential impacts on access and take-up.

Trends – Internet users

Rapid technological advances in ICT and a steady increase in the number of Internet users are affecting the way people communicate and do business, and are changing the global economy. Growing from 10 million users in 1993 (0.2% of global inhabitants), there were 2 billion Internet users in 2010 (29%). Internet use has been driven by non-tropical regions, where user numbers increased from 9.7 million in 1993 to 1.5 billion in 2010. In contrast, there were around 470 million Internet users in the Tropics in 2010 up from 230,000 in 1993. The Internet and World Wide Web originated in Europe and North America and until recently has been dominated by nations in these regions.

Despite the obvious disparity in absolute numbers, Internet user growth rates are higher in the Tropics, increasing at 30% per annum in the ten years to 2010, almost double the growth rate of 16% per annum in the Rest of the World. By 2010 the penetration rate had reached 17% in the Tropics (up from 0.01% in 1993), while it was 38% in the Rest of the World (up from 0.3% in 1993) (see Figure 8.4.3). The widespread introduction of wireless broadband services via mobile phones has contributed to strong growth in the Tropics (UNCTAD 2011). Despite this progress in the number of users, the gap in penetration rates between the Tropics and the

Rest of the World continues to increase, and was almost 22 percentage points by 2010.

The diffusion of the Internet across the eight Tropical regions has been uneven, and considerable disparities exist, with penetration rates ranging from 7% in South Asia to 38% in South America (see Figure 8.4.4).

Oceania initially led the way, with Internet user penetration rising from 0.5% in 1993 to 18% in 2005, driven by Australia and the United States. User rates in both nations exceeded 60% in 2005, while in many of the region's small island nations it was less than 5%. Since 2006 South America has had the highest penetration in the Tropics. All eight nations in South America have penetration rates of 30% or higher. Infrastructure expansion combined with competitive and flexible pricing by telecom companies and Internet service providers (ISPs) have contributed to strong take-up rates (Madory 2013).

In absolute numbers South East Asia has the largest number of Internet users in the Tropics, increasing from 0.12 million in 1993 to 173 million in 2010. This region accounts for more than one third of all Internet users in the Tropics in 2010. Improving Internet access from public facilities such as cafes, libraries and schools is also contributing to growth in many developing nations where household connections are often limited, and many people work in the informal economy. In Brazil and Peru over half of all Internet users log on from public facilities (UNCTAD 2009). More recently strong growth in Internet usage in the Tropics has been via mobile phones, notably in South East Asia (UNCTAD 2011).

Internet penetration in tropical South Asia, Central & Southern Africa and Northern Africa & the Middle East remains low by global standards, at 7%, 10% and 10% respectively in 2010. While cost and infrastructure limitations are known obstacles in these regions; unreliable electricity supply, low literacy rates, low computer literacy and limited awareness of the

Box 8.4.3 Internet access technologies

Over the past ten years an Internet connection has become just as important as a television, radio and telephone connection, and methods of connecting to the Internet have evolved considerably.

Initially, dial-up access via standard telephone lines was the only means to connect to the Internet. Over time technology has advanced rapidly, in line with demand for faster and more reliable services, and today broadband connections such as digital subscriber line (DSL)-enabled phone line, cable TV modems, wireless and fibre optic connections are increasingly common in developed nations. In most nations dial-up subscriptions now represent less than 10% of all fixed Internet subscriptions (ITU 2011). Nonetheless, dial-up still provides the only means of Internet access in many rural and remote areas where population densities are low and infrastructure costs are high.

Broadband is commonly used to describe Internet connections that are significantly faster than dial-up technologies, and which enable high-speed transfer of data, voice and video over the Internet. Broadband access

is typically classified as being either fixed or wireless. Fixed broadband currently provides the bulk of high-speed Internet connectivity. DSL and cable modem technologies have largely been built onto existing telecommunications networks, while fibre optic cable is a newer technology. DSL accounts for around 65% of the world's fixed broadband connections, followed by cable (ITU 2011).

Wireless technologies enable Internet access without the need for underground copper, fibre or other forms of network cabling. Compared to wired services, wireless technology provides greater convenience and mobility to connect to networks via portable modems, mobile phones or other mobile devices. Common wireless technologies include mobile broadband, WiFi and WiMAX.

Satellite links can be used to deliver broadband in remote or sparsely populated areas that are difficult or uneconomical to service using more conventional methods.



High speed broadband, Tonga. Tom Perry, World Bank.

Internet are also significant constraints (Kelly et al. 2012).

The availability of local language content is also a major influence on Internet use, and has contributed significantly to the disparity observed across the Tropics. Research suggests that making more content available in local languages can increase a nation's Internet subscription substantially (Samanta et al 2019). Around 90% of web content is in just ten languages, with English content making up 55%. Content is also available in at least another 150 languages (W3Techs 2013).

Trends – Fixed broadband subscribers

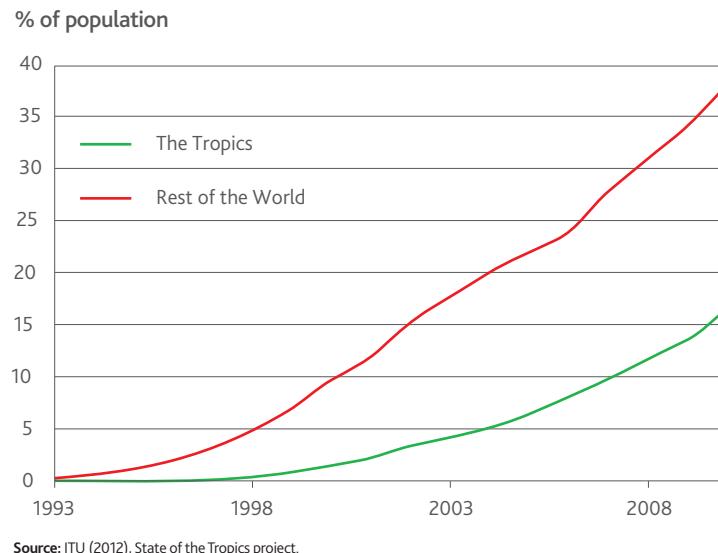
Globally, fixed broadband subscriptions have increased more than 30 fold in the ten years to 2010, from 16 to 521 million. Most of the increase occurred in the Rest of the World where subscriptions increased from 15 million in 2000 to 453 million in 2010. In the Tropics subscriptions increased by a factor of 100, from 670,000 to 68 million (see Figure 8.4.5).

Relative to the Internet though, fixed broadband diffusion is low, with global penetration increasing from 0.3% in 2000 to around 8% in 2011. As with other ICT indicators fixed broadband use in the Tropics lags the Rest of the World with the divide widening considerably over time. Both the Tropics and the Rest of the World had penetration rates of less than 1% in 2000, and by 2011 this had increased to just 2.6% in the Tropics, while in the Rest of the World it increased to 12.8%.

The limited number of fixed telephone lines in the Tropics, at eight per 100 inhabitants, (compared with 24 in the Rest of the World) is a major constraint to fixed broadband access in the Tropics.

With lower infrastructure costs, mobile access to broadband services is more common than fixed line services in both the Tropics and

Figure 8.4.3 Internet users



the Rest of the World. Nonetheless, a 'digital divide' exists between the two regions, with the penetration rate for mobile broadband in the Tropics being 6% in 2010, compared with 23% in the Rest of the World.

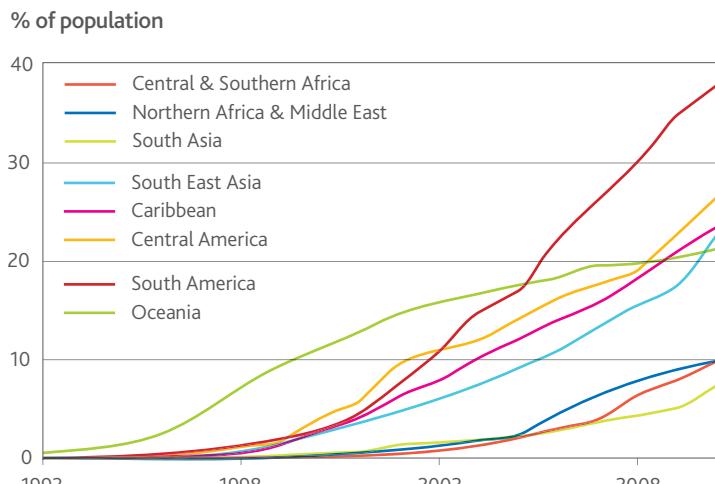
In 2000 when fixed broadband technologies were in their infancy, subscription rates in tropical regions ranged from zero (in four of the eight regions) to 0.3% (in Oceania). Subscription rates now range from less than 1% in Central & Southern Africa (0.1%), Northern Africa & the Middle East (0.6%) and South Asia (0.8%), to 7.4% in Central America (see Figure 8.4.6). Rapid increases in Central America are driven by Mexico, where fixed broadband subscriptions increased three-fold between 2007 and 2010, as the entry of three cable companies into the market increased competition (OECD 2012).

In Central & Southern Africa communications infrastructure is limited and fixed broadband subscriptions are low. The limited number of fixed telephone lines, inadequate terrestrial networks

between nations and high costs are critical factors constraining take-up. The cost of fixed broadband Internet services can be more than seven times the average income in some African nations (ITU 2012). The rapid diffusion of mobile communication promises to enhance Internet access in the region in the coming years.

Although national time series data on mobile broadband are not readily available, regional data report rapid increases in penetration rates since 2010 as technologies improve and telecommunications companies and consumers opt for more cost effective mobile services. In Africa for example, penetration rates for mobile broadband increased from 1.8% in 2010 to 10.9% in 2013, while the fixed line rate increased from 0.2% to 0.3%. Globally, growth in the number of mobile broadband subscriptions is more than five times that for fixed broadband subscriptions over the same period.

Figure 8.4.4 Internet users – the Tropics



Source: ITU (2012), State of the Tropics project.

Technology convergence

Over the past decade mobile broadband has redefined the way people access the Internet. Its greatest impact has been in developing nations, where lower infrastructure costs have encouraged investment and improved the affordability of high-speed Internet access in previously unconnected areas. Compared with fixed services, mobile broadband offers significant economies of scale and a more affordable means of reaching developing markets (World Economic Forum & INSEAD 2012). For example, in Cambodia, Indonesia, Kenya and Namibia fixed broadband penetration is less than 1%, while mobile broadband subscriptions range from 6% to 10% (ITU 2011).

Mobile broadband subscriptions surpassed fixed broadband subscriptions in 2008 (ITU 2011), supported by the development of 'smart' phones. An estimated 750 million people used a mobile phone to access the Internet in 2010, up from 180 million in 2005. Asian nations accounted

for more than half these users in 2010, with two-fifths of mobile Internet users from China alone (World Bank 2012a), and in many other developing nations, mobile broadband has emerged as the main platform for the Internet (GSMA 2012). With strong take-up, mobile data traffic is increasing at a staggering rate, and more than doubled in 2010 (World Economic Forum & INSEAD 2012).

Mobile communications in general, and broadband in particular, have a strong influence on the economies of rural areas in developing nations, where three out of four of the world's poor reside. The expansion of broadband networks into these areas has created new opportunities for non-agricultural employment, better-paying agricultural jobs and greater overall productivity. Access to broadband has also fostered small-business growth, allowing people in remote areas to work from home, and enabling rural businesses to compete more effectively in national and global markets. (World Bank 2009) (See Box 8.4.4).

Impacts of the internet and broadband

Greater access and use of internet and broadband technologies impact economic growth in several ways. They facilitate more efficient business processes (such as marketing, inventory and supply chain management), and accelerate logistics and consumer-focussed innovation (ITU 2012). Other economic benefits of Internet and broadband penetration include lower costs of trade facilitation, which can improve access to foreign markets and international trade. The Internet economy has also generated a multitude of innovative internet based companies, led to the development of entirely new business models and provided the basis for a broad range of new products and services, as well as transforming how consumers shop and corporations source inputs and sell products. In 2009 the economic benefits of e-commerce were estimated at US \$1.5 trillion, with expectations that it could reach US \$3.8 trillion by 2020 (ITIF 2010).

Nonetheless, of the technologies, broadband is recognised as having the greatest impact on economic activity, productivity and employment, in both developed and developing nations. A 2009 study suggests that in developing nations a ten percentage point increase in broadband penetration can yield an additional 1.1 percentage points (ppt) of GDP growth (compared with 0.8ppt in developed nations), while for broadband it is an additional 1.4 percentage points (compared with 1.2ppt in developed nations) (Qiang et al 2009). Along with its direct impacts on GDP, increased broadband penetration also contributes to significant job growth. In Latin America and the Caribbean in 2012 a ten percentage point increase in broadband penetrations was estimated to generate 67,000 new jobs (Zaballos & Lopez-Rivas 2012). Another study suggests that a US\$20 billion investment in third generation networks could benefit India's economy by US\$70 billion within a decade, and generate up to 14 million jobs (World Economic Forum & INSEAD 2012).

Table 8.4.2 Internet users - penetration

	1993		2000		2006		2010		1993 to 2010	
	%	Million	%	Million	%	Million	%	Million	PPT* change	Million
Tropics	0.01	0.23	1.5	35	6.4	215	16.5	471	16.6	473
Central & Southern Africa	0.00	0.00	0.2	1	2.0	19	9.9	67	9.8	68
Northern Africa & Middle East	0.00	0.00	0.3	0	2.2	6	9.9	14	9.9	14
South Asia	0.00	0.00	0.5	3	2.2	20	7.4	57	7.4	56
South East Asia	0.02	0.12	2.5	17	9.2	80	22.7	173	22.6	173
Caribbean	0.00	0.00	2.8	1	12.1	5	23.4	9	23.5	9
Central America	0.02	0.02	4.1	5	14.1	20	26.4	34	26.5	36
South America	0.02	0.04	2.7	7	17.0	64	37.9	113	37.9	113
Oceania	0.51	0.04	11.3	1	17.8	2	21.2	3	20.7	3
Rest of the World	0.30	9.66	9.7	355	21.8	916	38.0	1,520	37.8	1,520
World	0.20	9.89	6.4	390	15.6	1,131	29.1	1,991	29.0	1,992

Source: ITU (2013), State of the Tropics project.

* Percentage point.

Mobile broadband quality and cost

Despite rapid improvements in mobile technologies there are still considerable differences between fixed and mobile broadband services, with a major one being the speed, capacity and applications that mobile services can support. This can mean that mobile services are not entirely suitable for intensive users, particularly for some businesses and institutions.

High-speed, reliable broadband is particularly important for the delivery of e-commerce and public services such as those related to education and health. The potential benefit of broadband-delivered services may therefore

be constrained if they are delivered via mobile technologies, as is the situation in many developing nations in the Tropics. As applications become more bandwidth intensive it is anticipated that the broadband 'gap' will become a quality divide, and that people and businesses with low 'quality' broadband will be limited in their capability to generate economic and social benefits relative to those with higher quality services (World Economic Forum & INSEAD 2010).

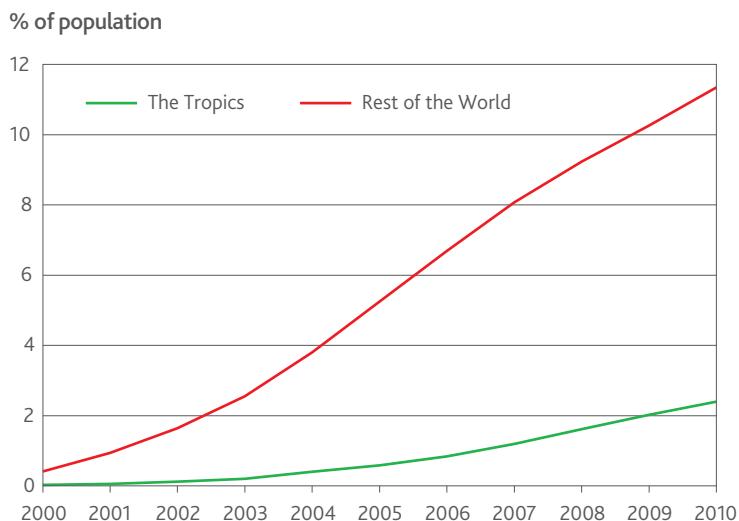
Infrastructure and access costs however represent a real hurdle to the rollout and take-up of broadband technologies, especially in poorer developing nations in the Tropics, where broadband is still unaffordable for many people. Although affordability in many nations

is increasing quite rapidly, the investment in handsets and other devices necessary to access mobile broadband can represent a considerable proportion of household income in many nations. For example, the basic costs of mobile telephony averages 7.5% of monthly GNI per capita in developing nations compared with 1.2% in developed nations. In Africa the figure is significantly higher at 16.7% (ITU & UNESCO 2011).

Internet security

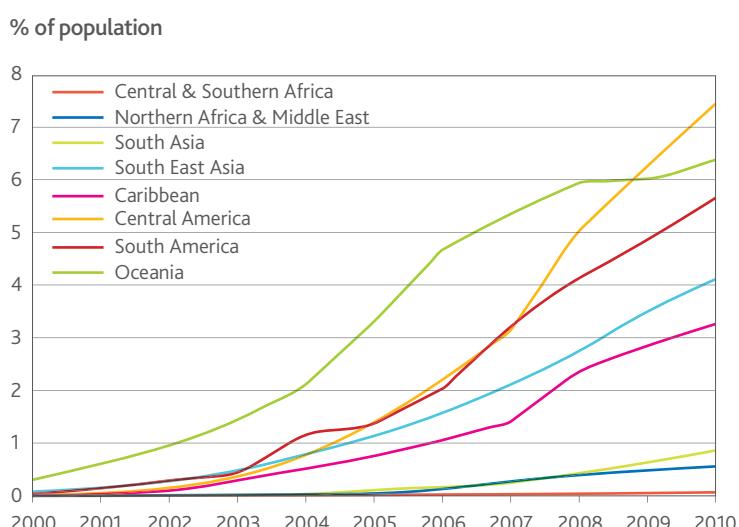
A significant economic impact of Internet technologies has been the development of e-commerce. The largest e-commerce markets are in the United States, the United Kingdom

Figure 8.4.5 Fixed broadband internet subscribers



Source: ITU (2012), State of the Tropics project.

Figure 8.4.6 Fixed broadband internet subscribers – the Tropics



Source: ITU (2012), State of the Tropics project.

and Japan at present, and e-commerce has been slow to drive economic growth in the Tropics.

In developing markets concerns over privacy, security, legal uncertainty concerning contracts and terms of delivery, and a lack of financial infrastructure have been identified as barriers to greater use of e-commerce. Cultural aspects have also affected the take-up of e-commerce in some developing nations.

Identity theft and online fraud have followed the growth of e-commerce and, where security is inadequate or uncertain, have undermined user trust in e-commerce and other services. For example, in Thailand, despite strong growth in the number of Internet users between 2006 and 2007 there was a lack of a concomitant increase in e-commerce, and 71% of users had never made an online purchase due to a distrust of electronic payment systems and credit card security (UNCTAD 2007). Nonetheless, in many nations there is a strong commitment to improve Internet security to maximise economic and other benefits (see Box 8.4.5).

Security is emerging as one of the more critical impediments to the e-commerce divide between the Tropics and the Rest of the World with significant differences reported in the use of security technologies between the two regions. The use of secure servers – the principal method of protecting information transmitted online – is less prevalent in the Tropics, with the number of secure servers sitting at 10 per one million people in 2010 compared to 255 per one million people in the Rest of the World.

Looking forward

ICT innovation over the past three decades has been a story of empowerment and growth. The Internet in particular has transformed the way people communicate, conduct business, learn and socialise. Given its increasing importance in today's society, not just as a means of communication and source of information, but also in terms of cultural, economic and political development, efforts need to be made

Box 8.4.4 Bangladesh

Small scale farmers in Bangladesh represent an important component of the economy. Although experienced and knowledgeable due to generations of on land learning, these farmers generally operate outside of the information society which limits their ability to respond to changing markets and safeguard themselves against shocks (Katalyst 2012). The government has attempted to provide information via an agricultural advisory service. However, geography and lack of infrastructure have historically restricted access to this service for those living in remote rural communities.

The 'Katalyst' program is a joint venture between an international non-profit-organisation and a local telecommunications operator. Under the program, Community Information Centres have been set up across the rural areas of Bangladesh to provide local entrepreneurs with access to mobile phone and Internet services which in turn connect communities to previously inaccessible networks and communication (Katalyst 2012).

The combination of multiple technologies (Internet, call centres and mass media links), make it possible to provide high/volume, low cost services for the benefit of both the providers and the rural users. The majority of the Community Information Centres are profitable and generate a daily income of US\$3-4 per day (I4D 2010). The program represents a shift in the mindset in the rural population in Bangladesh and allows farmers to access information quickly and cheaply. The programme has created an estimated 17,000 jobs in farms and small business, improved access to government helpline services and contributed to improved and safer incomes (I4D 2010).



Experimental farm, Bangladesh. Image: T Krupnik, CIMMYT.

Box 8.4.5 E-commerce in China

The take-up of e-commerce in China has been relatively slow, with concerns about digital piracy, identity theft and a lack of online payment options being significant roadblocks. Over half of the population cite privacy concerns as a major deterrent to online shopping, and of the 40 million small to medium enterprises in China in 2007, just 100,000 sold products online (ITIF 2010).

To address these low take-up issues a range of government and banking industry initiatives have been introduced to accelerate e-commerce capacity and growth. These have included developing laws, policies and technical standards. Specialised e-commerce supporting systems such as digital authentication and e-payments are also being developed to improve online payment options.

These developments, in combination with a rapidly growing Internet user base, have contributed to greater use of e-commerce. Between 2006 and 2009 the proportion of the population shopping online rose from 3% to 8%, but this is estimated to increase to 19% by 2012, with the value of online transactions projected to increase from US\$37 billion in 2009 to US\$100 billion in 2012 (ITU & UNESCO 2011). The majority of the growth in Internet and e-commerce has been in Beijing, Shanghai, and in Guangdong, which is located in the Tropics.



Guangzhou. Image: Ilya.

Table 8.4.3 Fixed and active mobile broadband subscriptions (per 100 inhabitants)

	1993		2000		2006		2010		1993 to 2010	
	Fixed	Mobile	Fixed	Mobile	Fixed	Mobile	Fixed	Mobile	Fixed	Mobile
Africa	0.1	n.a.	0.2	1.8	0.2	4.7	0.3	7.1	0.3	10.9
Arab States	1.6	n.a.	1.9	5.1	2.1	10.8	2.6	14.3	3.3	18.9
Asia & Pacific	4.7	n.a.	5.5	7.4	6.4	11.2	6.9	15.8	7.6	22.4
CIS**	6.1	n.a.	8.2	22.3	9.8	31.3	11.3	36.0	13.5	46.0
Europe	22.2	n.a.	23.6	28.7	24.8	36.6	25.8	50.5	27.0	67.5
The Americas	13.1	n.a.	14.1	22.9	15.0	33.6	16.0	39.8	17.1	48.0

Source: ITU (2013).

* Estimate. ** Commonwealth of Independent States (formerly the USSR). n.a. not available.

to expand Internet connectivity in developing nations both globally and within the Tropics.

The convergence of mobile telephony into the broadband space signifies the possibility of ubiquitous Internet access for the first time. Although great success has been achieved as coverage and access has increased in the Tropics, the process is far from complete. Much of the Tropics' population continues to live outside the range of a mobile network, and there are indications that the annual increases in coverage over the past decade are starting to slow down. The challenge that now remains is how to extend broadband to communities that are not commercially profitable, most notably in rural areas. Tropical nations that fail to develop affordable broadband Internet

services are likely to be at a social and economic disadvantage in the years to come as the world becomes increasingly interconnected.

To achieve the expansion of broadband requires top-level political leadership and joint efforts by the private sector and by governments. Most important of all, these efforts should be coordinated across all sectors of industry, administration and the economy. Developing isolated projects or piecemeal, duplicated networks, is not only inefficient; it also delays provision of infrastructure that is becoming as crucial in the modern world as roads or electricity supplies.

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Women with mobile phone, India .
Image: Erik Newth



Kalahari, Namibia.
Image: Vice.



Essay 5

Expansion of the Tropics – Evidence and implications

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Expansion of the Tropics

Dr Joanne Isaac & Professor Steve Turton.

There is accumulating evidence that the tropical zone is expanding poleward in both hemispheres, and that the subtropics are also expanding into regions which have previously enjoyed a more Mediterranean climate. This essay is a follow-up to an initial report by the same authors conducted in 2009; there has been considerable further work in this field since 2009 and so we include up-to-date research, investigate how thinking has changed, or not, and whether predictions from five years ago still hold true.

A poleward expansion of the tropical and subtropical zones is likely to have significant consequences for a number of the issues raised in the State of the Tropics Report (2014), including the peoples of the Tropics, and for ecosystems and biodiversity.

For example, The State of the Tropics report highlights that the resources required to sustain larger populations and economic growth are putting significant pressures on the natural environment in tropical regions. An expansion of tropical regions will only increase these demands further, and may also cause a shift in ecosystems as some regions will become drier, and others may see more frequent heavy rain events.

The Report also highlights the fact that almost half the human population of the Tropics is vulnerable to water stress – a shift in climatic zones, and potentially drying in regions currently neighbouring the subtropics could increase the number of people who are at risk.

Furthermore, the State of the Tropics report finds that despite improvements in health and nutrition over the past 50 years, the Tropics still bears a 'disproportionate share of the global burden of many communicable and preventable diseases.' An expansion of the tropical zone could increase the prevalence of many diseases, particularly vector-borne diseases, as more areas become climatically suitable for insect vectors.

Introduction

Climate change is unequivocally one of the most important threats facing humanity and the environment (Williams et al. 2008; IPCC 2014). Documented changes already include warming of the atmosphere and ocean, melting of snow and land and sea ice, rise in sea levels and increases in concentrations of greenhouse gases (GHGs) to unprecedented levels (IPCC 2014). While some of the earliest signs of climate change included the warming of temperate regions and the melting of ice in the Arctic, a suite of studies have demonstrated significant impacts in tropical regions which are likely to be disproportionately affected (eg refs of some of the 'suite of studies'). The most recent IPCC Working Group II Report (2013) states that, with high-confidence 'relative to natural internal variability, near-term increases in seasonal mean and annual mean temperatures are expected to be larger in the Tropics and subtropics than in mid-latitudes'.

Additionally, long-term meteorological measurements indicate that climate-driven changes may be responsible for the expansion of the earth's tropical zone (reviewed by Seidel et al. 2008, IPCC 2013, Lucas et al. 2014).

The tropical zone is commonly defined as the portion of the Earth's surface that lies between the Tropic of Cancer at 23.5° north latitude and the Tropic of Capricorn at 23.5° south. The origin of this Cartesian definition lies in astronomy, as these lines mark the northern and southern-most points on the Earth where the sun reaches its zenith at solar noon during the boreal (June 21) and austral (December 21) summer solstices.

However, the definition of the Tropics varies among scientific disciplines, and climatologists use different indicators to define the boundaries of the Tropics, commonly based on surface temperature and precipitation patterns (Seidel et al. 2007). Another, easily tracked characteristic of the Tropics lies high above the Earth, at the boundary between the troposphere, the lowest layer of the earth's atmosphere where weather systems form, and the stable stratosphere above it. This boundary is

known as the tropopause and is at its highest over the Tropics where it can reach 18 km in altitude, while over the poles it occurs at around 8 km. Thus, the height of the tropopause is another feature used by climatologists to define tropical regions. In general, climatologists and meteorologists estimate the boundaries of the Tropics extend further from the equator than the traditional Cartesian definition, to around 30° latitude north and south of the equator. This latitude roughly separates the generally slow moving tropical and subtropical air masses from the highly mobile air masses that typify the weather and climate of the mid-to-high latitudes.

The tropical zone is straddled by the less well-defined subtropical zone, the climatic region found adjacent to the Tropics, usually between 20 and 35 degrees latitude in both hemispheres, but occasionally found at slightly higher latitudes.

Tropical regions are characterised by a warm to hot climate, with comparatively smaller seasonal changes in day-to-day temperatures compared to other regions. Another important feature of the Tropics is the prevalence of rain in the moist inner regions near the equator – the 'deep Tropics' - which distinguishes tropical regions from the much drier conditions of the subtropics, where the world's major desert regions are located (Seidel et al. 2007). Seasonality of rainfall in the Tropics increases with distance from the equator.

How much has the tropical zone expanded?

In 2009, we reviewed a number of, then current, studies employing varying methodologies to measure the expansion of the tropical zone. For example, Hudson et al (2006) used long term satellite measurements of ozone concentration and estimated that the area of the northern hemisphere occupied by the Tropics had expanded by approximately 1° latitude per decade in the period 1979–2003 – a total widening of 2.5°. Fu et al. (2006), over the same time period, used satellite temperature observations from 1979–2005 and estimated a

slightly lower widening of 2° latitude across both hemispheres, while Seidel and Randal (2007) - using data from weather balloons and climate models - estimated a significantly larger increase of between 5 to 8° in the same period.

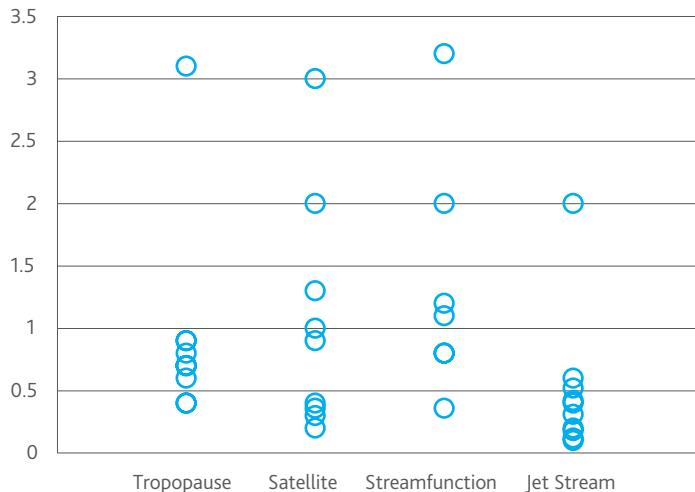
Since our initial review, there have been a number of new studies that have estimated the total widening of the tropical zone, recently reviewed by Lucas et al. (2014). There are now at least 32 different estimates of the degree of expansion of the tropical zone - across different time periods (Figure E5.1). An updated mean of the estimates is slightly lower than in 2009, at around 0.5 – 1.0° per decade (summarised in Lucas et al. 2014). However, considerable variation is evident among the estimates, possibly in part due to the different methodologies that have been employed in the studies and the number of years comprising the data.

A thorough critique of these methodologies can be found in Lucas et al. (2014); however we will briefly review the four main ways researchers have estimated the degree of widening of the tropical zone:

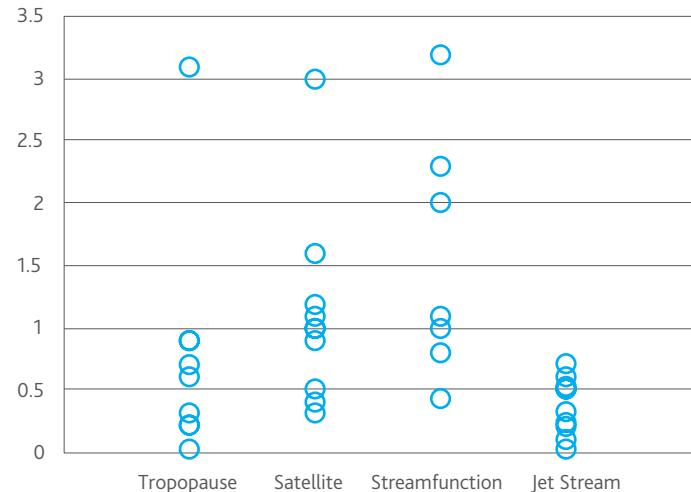
- Tropopause methods: this method uses the tropopause height frequency to estimate widening of the Tropics both vertically and horizontally. This method is sensitive to the choice of the tropical tropopause threshold and the definition of the tropical edge. Studies using this method generally estimate a horizontal widening of less than 1° latitude per decade, although there is some variation.
- Satellite methods: Various metrics, such as outgoing long-wave radiation from satellite-based platforms have also been used to investigate expansion. Differences between data sets are large using these methods, and
- Stream-function methods: This metric is the edge of the Hadley Circulation (described below) derived from calculation of the (isobaric) mass stream-function. It generally gives a lower estimate of expansion, averaging less than 0.8° latitude widening per decade in both hemispheres, and shows seasonal differences.
- Jet Stream Methods: this method uses the change in the position of the various jet streams to estimate tropical expansion. Estimates using this method average the lowest of all the different methodologies, around 0.2° latitude per decade.

Figure E5.1 **Figure 1: Summary of studies which have provided an estimate of the degree of expansion of the tropical zone for a) the southern hemisphere, and b) the northern hemisphere (data collated from Lucas et al. 2014)**

Degree expansion/decade



Degree Expansion/Decade



Thus, while evidence has continued to accumulate for the widening of the tropical zone, the estimates now suggest a lower degree of expansion than was reported in our 2009 review. In their recent review, which used all known published estimates, Lucas et al. (2014) found an average trend of $0.5 - 1.0^\circ$ in latitude expansion per decade, translating to $1.25 - 2.5^\circ$ per 25 years, or $138 - 277$ km. This is much reduced from the estimate of 222 to 533 km per 25 years taken from studies we reviewed in 2009.

In 2006, Fu et al. (2006) also suggested a stronger longitudinal trend for an expansion of the tropical zone in the southern hemisphere, compared to the northern hemisphere. A number of more recent studies have also found a similar trend (i.e.: Lu et al 2009, Birner 2010, Davis and Rosenlof 2012), however this seems more common in studies utilising the troposphere method. Other studies have found the opposite, with the Northern Hemisphere having greater expansion (i.e.: Zhou et al 2011, Hu et al 2011, Hu and Fu 2007) – this seems to be most common in satellite-based studies. Theoretically, one would expect great expansion in the northern hemisphere due to its land dominance compared with the moderating influence of the Southern Ocean in the southern hemisphere. Currently any potential asymmetry in expansion between the north and southern hemispheres is still unclear and may be a methodological artifact.

In addition to observations of the poleward expansion of the tropical zone, studies also suggest that the height of the Tropics, as measured by the height of the tropical tropopause, has also increased by some tens of metres over the past few decades (Seidel and Randal 2007; Zhou et al. 2001; Santer et al. 2003). Taking all estimates into account, Seidel et al. (2008) proposes that the overall three-dimensional growth of the tropical zone over the 25 years prior to 2008 was around 5%.

However, measuring tropopause height is controversial, sensitive to methodology and also varies across seasons (Lucas et al. 2014). For example, a 2010 study by Birner found that using

statistics of tropopause height to distinguish between Tropics and extratropics (areas outside the tropical zone) in studies was problematic, and that widening trends were particularly sensitive to changes in the tropopause height threshold.

Additionally, a number of studies have identified shifts and changes in intensity in tropical circulation systems and climatic phenomenon. The primary driver of the climate in the Tropics and sub-tropics is the Hadley Circulation (HC) system, which can be most simply explained as a large-scale overturning of the atmosphere in the tropical zone, driven by latitudinal heating gradients (Webster 2004). The HC system drives the trade winds – and the point at which the trade winds of the northern and southern hemisphere converge and rise is known as the intertropical convergence zone (ITCZ). The ITCZ is a high-precipitation band of thunderstorms and results in the high rainfall patterns typical of the tropical equatorial zone. Following the loss of water vapour over the equatorial Tropics, the descending air dries out and moves further north and south towards higher latitudes. As this dry air begins to sink back toward Earth's surface over the subtropics, it warms, driving evaporation. This is the mechanism leading to the dry conditions experienced in many subtropical regions.

In 2006, Hu and Fu found a poleward expansion of the HC of between 2.0 to 4.5° in each hemisphere since 1979, concluding that this implied a poleward shift of the tropical and subtropical zones. In a more recent analysis, Hu et al. (2011) find a smaller, but still significant expansion of the HC from 1979 -2009 of around 1.23° in latitude in both hemispheres, based on a number of different methods. Similarly, extensive re-analysis by Nguyen et al. (2013) showed an expansion of the HC in both hemispheres of around 1.6° latitude per decade. However they found that this expansion was seasonal and most pronounced and statistically significant during summer and autumn. Choi et al. (2014) recently found a significant poleward shift of the southern edge of the HC, during the austral summer (November-March), from the South Atlantic Ocean eastward to Australia. This is estimated to

be equivalent to around 0.22° per decade from 1980 – 2012.

Sachs et al. (2009) indicated that the ITCZ had also moved poleward and was now located more than 500km farther away from the equator than previously; equivalent to a shift of around 4.5° in latitude. The authors estimate the ITCZ is moving poleward in the northern hemisphere at a rate of approximately 1.4 km per year (Sachs et al. 2009). A more recent analysis confirms that the ITCZ is extremely sensitive to high- and low-climate forcings (factors that influence climate – such as energy from the sun, volcanic eruptions, etc), and depending upon cooling or warming conditions, can migrate $\pm 7^\circ$ in latitude from its usual position over the Atlantic Ocean (Arbuszewski et al. 2013). Thus, these estimates of the latitudinal expansion of the HC and ITCZ generally fit with studies which demonstrating an expansion of the tropical zone, but can be subject to methodological and temporal/seasonal variability.

Shifts in other climatic phenomenon have also been reported for the same period. For example, a number of studies show a longitudinal, westward extension of around 10° in the Western Pacific subtropical high (WPSH) over 30 years (Ho et al. 2004; Wu et al. 2005). This is significant, as the WPSH is the predominant driver of climate and precipitation patterns across Asia. Hu and Fu (2006) suggest that other changes in more regional circulation patterns, such as the WPSH, may also be contributing to the general expansion of the tropical zone.

Mechanisms behind a tropical expansion

In addition to a general lack of consensus regarding the magnitude of shift, there has also been considerable speculation regarding the proximate and ultimate mechanisms resulting in the widening of the tropical zone (Lucas et al. 2014). In our initial review, research suggested a role for climate change in the expansion of the tropical zone, and associated changes in climatic events and circulations systems. At that time, the IPCC

in their Fourth Assessment Report (2007) stated that increases in greenhouse gases and associated changes in climate could lead to a variety of changes in atmospheric and climatic phenomenon, including warming of the troposphere, cooling of the stratosphere, rise of the tropopause and a weakening of tropical circulation patterns – all of which may contribute to an expansion of the tropical zone. Hu and Fu (2006) further suggested that an increase in sea surface temperatures (SST) in the Tropics, associated with climate change, could result in an increase in the height of the tropopause and a wider HC.

Since then, numerous studies confirm that the tropopause is indeed warming (reviewed by Thorne et al. 2010), with the majority also suggesting a strong human influence (i.e.: Santer et al. 2013). As a result, the Fifth Assessment Report of the IPCC (IPCC 2013), is much clearer, and certain, on the warming of the troposphere, stating 'It is virtually certain that globally the troposphere has warmed since the mid-20th century. More complete observations allow greater confidence in estimates of tropospheric temperature changes in the extra-tropical Northern Hemisphere than elsewhere. There is medium confidence in the rate of warming and its vertical structure in the Northern Hemisphere extra-tropical troposphere and low confidence elsewhere.'

Anthropogenic factors are thought to influence the troposphere and other climate systems in a variety of ways, and many recent studies have focused on the role of GHG emissions (particularly CO₂), ozone depletion and aerosols in climate forcing and tropical expansion.

In 2009, Lu et al. used the height of the tropopause to characterise the tropical zone, and demonstrated that the observed widening of the Tropics can only be accurately replicated by an atmospheric general circulation model that includes direct radiative effects related to human GHG emissions and stratospheric ozone depletion.

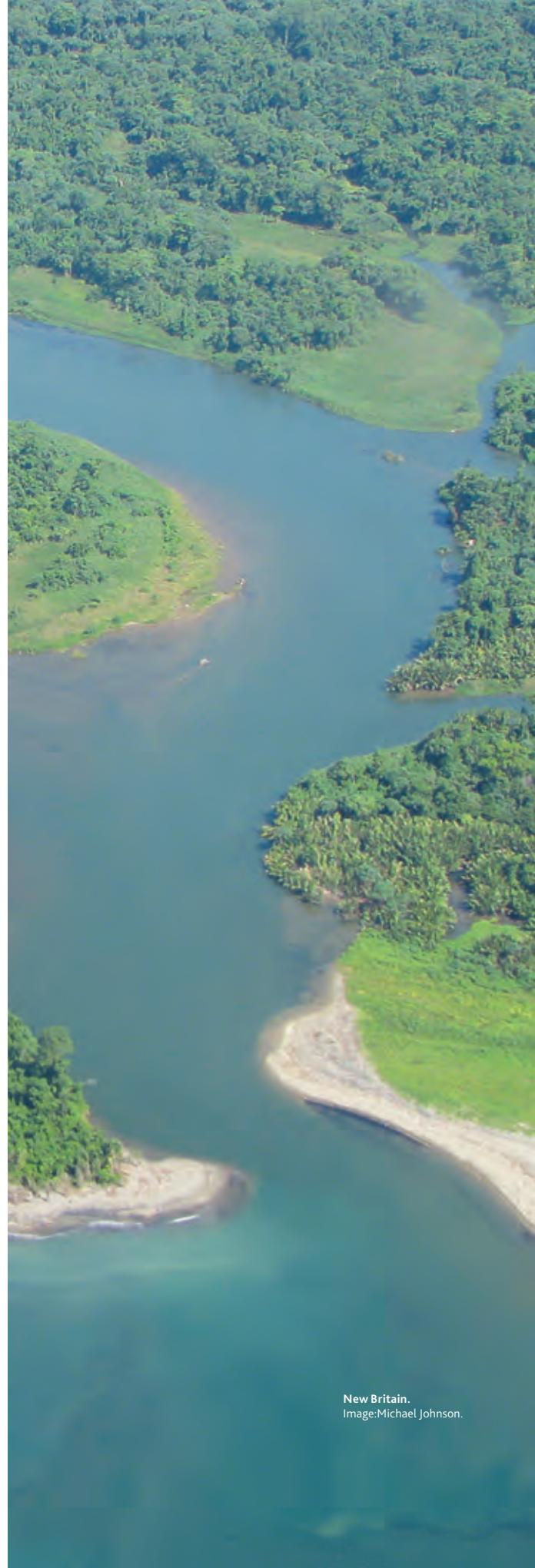
More recent studies have attempted to clarify the relative role of GHGs and ozone depletion. A warming of the troposphere raises the height

of the tropopause, as does a cooling of the stratosphere (the layer of the earth's atmosphere above the troposphere – approximately 50 km above the earth's surface). An initial report by Santer et al. (2003) provides support for warming of the troposphere and cooling of the lower stratosphere over the last four decades of the 20th century, and indicates that both of these changes in atmospheric temperature have contributed to an overall increase in tropopause height.

Essentially it is thought that the radiative forcing (the difference between energy from sunlight received by the Earth and energy radiated back to space) of GHGs cause upper tropospheric heating, and potentially stratospheric cooling, resulting in a poleward shift in the mid-latitude jetstream and an expansion of the HC (e.g.: Previdi and Polvani 2014). Evidence suggests that stratospheric ozone is being destroyed by a group of manufactured chemicals which contain chlorine and/or bromine. These ozone-depleting substances (ODS) are safe in the lower atmosphere, but float up into the stratosphere where they are broken apart by the intense ultraviolet light, releasing chlorine and bromine (IPCC 2013).

The contribution of aerosols in the expansion of the tropical zone has gained much attention in recent years, and of primary interest has been black carbon (BC); BC is formed by the incomplete combustion of fossil fuels and can cause global warming by absorbing heat in the atmosphere. It is also thought to reduce the ability to reflect sunlight, or albedo, when deposited on snow and ice. Aerosol forcing of the climate may be significant (Lucas et al. 2014), and may occur when heating associated with absorbing aerosols changes relative humidity and impacts the lifetime of clouds.

However, the relative contribution of GHGs, ozone depletion and BC aerosols in the expansion of the tropical zone and associated climatic forcings is still unclear, with studies finding conflicting results. In a recent analysis, Santer et al. (2013) find that warming of the troposphere is mainly driven by anthropogenic GHG emissions, while cooling of



New Britain.
Image:Michael Johnson.

the lower stratosphere is primarily attributable to human-caused stratospheric ozone depletion. Similarly, Lu et al. (2009) found the widening trend in the tropical zone could be attributed entirely to direct radiative forcing, in particular related to greenhouse gases and stratospheric ozone depletion, while Hu et al (2013) found that widening and poleward shift of HC are caused by anthropogenic forcings and particularly increasing GHGs.

Other studies implicate BC, with Rostatyn and Lohmann (2002) finding that the indirect aerosol effect has been found to potentially drive the observed southerly shift in the ITCZ, and BC has been implicated in a northward displacement of the ITCZ and a strengthening of the HC in the Northern Hemisphere (Wang 2007).

In a recent study published in *Nature* (Allen et al. 2012), BC and tropospheric ozone were found, in models, to better explain the observed expansion of the tropical zone in the Northern Hemisphere than were GHGs. The authors note that atmospheric heating in the mid-latitudes from BC and tropospheric ozone has generated a poleward shift of the tropospheric jets.

The role of increasing sea surface temperature (SST), due to climate change, remains unclear, with studies giving conflicting results. For example, Lu et al. (2009) conclude that SST forcing causes no significant change in the width of the Tropics, and even a contraction in some seasons. However, Allen et al. (2014) state that tropical expansion and contraction are influenced by sea surface temperature variability, which is associated with both the Pacific Decadal Oscillation (a long-lived El Niño-like pattern of Pacific climate variability) and anthropogenic aerosols.

Studies have also identified that natural events and natural variation can impact on the expansion of the tropical zone. Volcanic eruptions, which inject sulfur dioxide into the atmosphere, typically result in cooling on the earth's surface and in the lower atmosphere. They thus have the opposite effect of BC aerosols and absorb radiation – warming the lower stratosphere, and cooling and

lowering the tropopause, and potentially thus contraction of the tropical zone (Santer et al. 2003; 2014). The IPCC (2013) stated that several small volcanic eruptions have contributed to radiative cooling from 2008-2011.

In summary, there is still no clear consensus on a single primary forcing mechanism behind the observed expansion of the tropical zone (Lucas et al. 2014). To date, studies and modeling indicate that several interacting factors are likely involved, including anthropogenic GHGs, black carbon and warming sea surface temperature. Volcanic eruptions may contribute to temporarily reverse expansion, and cause contraction.

The implications of an expansion of the tropical zone

The Tropics currently occupy approximately forty percent of the Earth's land surface and are home to almost half of the world's human population, and account for more than 80% of the Earth's terrestrial biodiversity (e.g. Rosenzweig 1995; State of the Tropics 2014). The majority of the world's endemic plants and animals are also found in the Tropics, where they are commonly adapted to the specific climatic conditions found there. Thus, the implications of a poleward expansion of the tropical and subtropical zones are immense and the effects could result in a variety of social, economic and environmental implications (Seidel et al. 2008), which will be discussed in the following sections.

Drought, drying and shifts in climatic zones

In our initial review, we highlighted a number of predicted scenarios from researchers investigating the observed expansion of the tropical zone. At that point in time (2009), the most important predicted consequence was the poleward extension of the subtropical dry zone - bringing drought conditions to regions which currently have a temperate climate with predictable winter rainfall (Seidel et al. 2008). Fu et al (2006) also demonstrated a robust pattern of warming in the mid-latitudinal region, from around 15 to 45° latitude in both hemispheres, indicative of

a poleward shift which was predicted to lead to mid-latitude tropospheric warming and contribute to an increased frequency of droughts in both hemispheres (Fu et al. 2006; Seidel et al. 2008). Of particular concern under these predictions were regions bordering the subtropics which currently experience a temperate 'Mediterranean' climate, including heavily populated regions of southern Australia, southern Africa, the southern Europe-Mediterranean-Middle East region, the south-western United States, northern Mexico, and southern South America – all of which were predicted to experience severe drying (Seager et al. 2007; Seidel et al. 2008).

In 2009, the fingerprint of a poleward march of the subtropics into temperate regions was already becoming evident; climate models from the IPCC (2007) were predicting droughts for regions of the Mediterranean and the south-west of the US, while Seager et al. (2007) similarly forecast that southwestern North America would see an imminent shift to a more arid climate. The south-western state of California was, at that time, already in the grip of a multi-year drought (California Department of Water Resources 2008) and significant drying had been observed in the south-west of Western Australia over the previous 50 years, although other Mediterranean climates in Australia (e.g. South Australia) had experienced less significant declines (Bureau of Meteorology, Australia 2009).

More recent studies indicate that some of predictions may indeed be becoming a new reality. Shin et al. (2012) investigated the expansion of areas of dry climate, comprising steppe and desert climates, in relation to the observed intensification of the HC. They find some evidence of an expansion of these climatic zones from 1950 – 2000, concomitant with an enhanced intensity of the HC was enhanced, particularly during the boreal winter (November – March) and conclude an observational linkage that connects desertification with intensification of Hadley Circulation. Polovina et al (2011) further project that the area of the subtropical region will expand by 30% by 2100.

There are also indications of an increase in drought conditions in areas bordering the subtropics. For example, in 2011, the USA state of Texas experienced its worst single-year drought in history, during a drought period beginning in 2010, and currently still continuing (e.g: Seager et al. 2014) – this drought has also affected the neighbouring state of New Mexico to the west. Severe drought conditions are also continuing to impact the state of California (Aghakouchak et al. 2014).

In south-western Western Australia, low rainfall persists and some regions recently experienced the lowest precipitation conditions on record (BOM 2014). Post et al. (2014) also confirm an ongoing expansion of the HC, of 0.5° latitude per decade, leading to a reduction in winter rainfall and run off in southern Australia. Cai et al. (2012) confirm that a poleward shift of the sub-tropical dry-zone explains most of the decline in rainfall in southeastern Australia during April-May. Increasing droughts have been noted also in the Mediterranean Basin (Hoerling et al. 2012), South America (Morales et al. 2012) and China (Ye 2013).

However, how much of this drying can be attributed to the expansion of the subtropical zone remains unclear. Cai et al. (2012) examined the role of tropical expansion on the drying trend apparent in some southern hemisphere regions during austral autumn (March-May). They found rainfall reduction coincided with a poleward expansion of the tropical and subtropical dry zones by around 2° – 3° latitude in the same season. However, while their results show that a poleward shift of autumn rainfall may explain most of the southeastern Australia rainfall decline, it explains only a small portion of the southern Africa rainfall trend and none of autumn drying over southern Chile.

Eastman and Warren (2013) investigated changes in global cloud cover, and find a small decline of 0.4% per decade. However, the trend is primarily attributed to declining clouds in the middle latitudes – particularly across South America and Australia, which both showed continent-wide decreases in total cloud cover. They link cloud

changes to the observed poleward shift of the jet streams in both hemispheres. Similarly, Polade et al. (2014) investigated the future increase in dry days in subtropical regions, concluding that many regions could see up to 30 more dry days per year by the end of this century, and that over most of the subtropics, the change in number of dry days dominates the annual changes in precipitation

A decline in visibility, due to an increase in conditions leading to smog, has also been associated with the intensification and westward extension of the WPSH in eastern China. A decline of 1.4 km of visibility per decade has been estimated, equivalent to 34% over 37 years, linked to more days with stable, hot and humid weather (Qu et al. 2013).

Recent studies also implicate some of the pollutants associated with tropical widening, such as the indirect aerosol effect and black carbon, as drivers of drought. For example, the indirect aerosol effect has been associated with a southward shift in the ITCZ, potentially associated with past Sahelian drought (a climate zone between the African savanna grasslands to the south and the Sahara desert to the north, across West and Central Africa; Rotstayn and Lohmann 2002). Changes in cloud type associated with the Indian monsoon are also consistent with the suggestion that BC could be affecting monsoonal precipitation and causing drought in northern India (Eastman and Warren 2013), while Turner and Annamalai (2012) found that BC could intensify the Asian summer monsoon.

If the dry subtropics belt expands into regions more used to a temperate, wet winter season, there will be consequences for water resources, natural ecosystems and agriculture, with cascading social and health implications (Fu et al. 2006; Seidel et al. 2008). In many tropical regions, more than 90% of the population works in agriculture and, since water dictates tropical agriculture, variability of climate may be responsible for economic weakness in such areas (Balek 1983). The State of the Tropics report (2014) notes that current water use patterns are considered unsustainable in many tropical regions;

agriculture accounts for 81% of water withdrawals in the Tropics compared with 69% globally. Historical records show that higher growing season temperatures have dramatic impacts on agricultural productivity, farm incomes, and hence food security (Battisti and Naylor 2009). Thus, increasing drought could lead to large scale human migrations as people search for jobs, which may lead to overcrowding, violence, disease outbreaks and pressure on local resources in neighbouring areas (Matthew 2008). Droughts and global food crises have recently been implicated as a causal factor of riots and violence in a number of regions, including South Africa (Bar-Yam et al. 2013). Studies already demonstrate that climate change related drought in developing countries can result in the loss of human lives to hunger, malnutrition and diseases, the emergence of environmental refugees, and the collapse of national economies (Battersby and Warren, 2001; Mortimore and Adams, 2001). For example, the Sahel region, which borders the southern edge of the Sahara desert in Africa, has seen a decline in per capita food production following drought, exposing many people to food insecurity and income poverty (Battersby and Warren, 2001).

However, while many regions are predicted to become hotter and drier, some may experience more rain. For example, studies suggested a poleward expansion of the ICTZ may also bring increased precipitation to areas at a greater distance from the equator, while areas close to the equator may receive less rainfall (Sachs et al. 2009) and also that wetter, higher-latitude regions may become wetter still and experience extreme rainfall events (Seager et al. 2007). In 2009, severe flooding affected the normally arid northeastern region of Brazil apparently due to an anomaly in the path of the ITCZ, while Southern Brazil was gripped by drought – events potentially related to the poleward movement of the ITCZ in the northeast and the expansion of the dry subtropics to the south.

Furthermore, due to the apparently simultaneous shift of other climatic events, such as the WPSH, some regions, particularly parts of Asia, actually appear to experience a cooling effect, rather



Bali.
Image: Andy Holt.

than the more widespread warming (Gong and Ho 2002, Hu et al. 2003, Fu et al. 2006). There is some evidence that the severe polar vortex affecting the north east USA - following drought in California - was influenced by GHG emissions and poleward shifts in other climatic phenomena (Wang et al. 2014).

Shifts in tropical cyclone tracks and activity

In 2009, a number of climate scientists were predicting a poleward shift in the paths of extra-tropical and tropical cyclones over the next 100 years (Yin 2005; IPCC 2007; Walsh and Kafney 1999). However, others were arguing that increased vertical wind shear and upper tropospheric warming might negate some effects (e.g.: Vecchi and Soden 2007). Extra-tropical storms, also known as mid-latitude cyclones, occur within the mid-latitudinal band from around 30° to 60° latitude in both hemispheres and studies have documented a poleward shift in the mean latitude of extra-tropical cyclones, by about 2°, over the past 60 years (McCabe et al. 2001; Fyfe 2003).

More recent studies add observational support for a change in storm tracks; for example Bender et al. (2012) find a poleward shift in extra-tropical storm tracks between 1983–2008, while Solman and Orlanski (2013) find an enhancement of the frontal activity shifted to higher latitudes in the northern hemisphere. Similarly, ozone depletion has been associated with a poleward shift in cyclone frequency over the Southern Ocean, but with minimal influence on intensity and lifetime (Grise et al. 2014). Significantly, a very recent study shows a poleward shift in the area of maximum intensity in cyclones in both the Northern and Southern hemispheres, of 53 and 62 km per decade respectively; equivalent to a shift of around 2.5° in latitude per 25 years (Kossin et al. 2014). Shifts in the behavior and tracks of cyclones in Australia have also been noted with tropical cyclone activity is currently at its lowest in Queensland and Western Australia for many centuries (Haig et al. 2014). However, Haig et al. (2014) caution that while there will be fewer cyclones, cyclones that do hit will be of higher intensity.

The shifts in tropical storm tracks have been related to enhanced warming in the tropical upper troposphere and increased tropopause height (Yin 2005); there is also some evidence that the degree of shift is likely to be greater in the mid-latitudes of the southern hemisphere (IPCC 2007; Yin 2005). Predictions were for greater cyclonic activity at higher latitudes in both the tropical and mid-latitude bands (IPCC 2007), increasing flood risk in regions not prepared for extreme precipitation events.

A change in the activity and tracks of tropical cyclones has been noted in some regions. For example, tropical cyclone Gonu tracked unusually far to the northwest into the Gulf of Oman in 2007, hitting landfall in Oman and Iran, a region with no known records of having been hit by a cyclone (WMO 2008). Similarly, in Asia there has been a significant westward shift in typhoon (cyclone) tracks over the past 40 years, resulting in greater storm activity in subtropical East Asia but a decline in typhoons over the South China Sea. 2004 saw a record number of storms hit Japan, while South China faced drought due to a lack of land falling typhoons, and the authors suggest this shift is related to the westward movement of the WPSH (Wu et al. 2005).

More recent studies highlight further changes in cyclone activity; black carbon and other aerosols have been implicated in causing intensification of cyclones in the Arabian Sea region, with significant impacts expected for human health (Evan et al. 2011). In Taiwan, cyclone frequency has almost doubled since 2000, consistent with a northward shift of the typhoon track over the western North Pacific-East Asian region, and an increase of typhoon frequency over the Taiwan-East China Sea; the authors associate these changes with the weakening of the Western North Pacific subtropical high (Tu et al. 2009). Finally, Murakami (2013) finds a decline in typhoon frequency over western Japan and the Korean peninsula, but an increase over eastern Japan, related to the southward shift of the subtropical jet stream.

The economic costs of increasing extreme weather events such as drought, extreme heat

waves, flooding and destructive winds, could be considerable. Since the 1950s, the global costs of extreme weather events have risen by around six orders of magnitude, with much of the increase occurring since the late 1980s (UNEP 2005). The total cost of extreme weather events in the USA, in 2011, was estimated to be over US\$53 billion, not including health care (NRDC 2011). Extreme weather events resulting in destruction of crops could also be considered a global food security issue (Brown and Funk 2008).

Impacts on biodiversity

Biodiversity is greater in the Tropics across most taxonomic groups, with an equivalently higher proportion of threatened species. For those plants and animals for which there are adequate data, loss of biodiversity is greater in the Tropics compared to the rest of the world (State of the Tropics 2014). The Tropics contains more biodiversity 'hotspots' (Myers 2000) and more endemic species than any other region. In 2009, there was accumulating evidence that many animal and plant species were moving poleward in an attempt to track their preferred climatic conditions (e.g. Parmesan and Yohe 2003) and since then documented range shifts have been reported in many species from many different taxa, including those in the Tropics (e.g.: Chen et al. 2011, Vanderwal et al. 2013).

In 2003, Parmesan and Yohe (2003) estimated that species around the globe had moved 6.1 km per decade towards the poles. Converting this to a 25 year average, in line estimates of the expansion of the Tropics in earlier sections, this means that most species were predicted to move only around 15 km, or 0.13 ° in latitude – implying that the poleward movement of most plants and animals would lag behind the movement of climatic zones by at least 207 km, or 1.87° latitude based on the most conservative estimates at that time – which could potentially lead to species loss and extinction in the Tropics.

A more recent meta-analysis (Chen et al. 2011) found that - on average - species have moved at 16.9 km per decade, equivalent to 42.24 km or 0.38° latitude in 25 years – more than twice

as fast as the estimate from Parmesan and Yohe (2003) in their seminal paper. Combined with the revised lower average estimates of the poleward shift of the tropical zone (see previous section), the lag between species and climate zones is now estimated to be at least 0.87° latitude or 96 km. While this indicates that plants and animals are shifting their range quicker than was previously thought, it still means they are lagging almost 100 km behind potential physical shifts in climate (and, as a result, vegetation) zones. However, the response of species to climate change is likely to be far more complex, and VanDerWal et al. (2013), using 60 years of Australian climatic data and changes in climatic niche space in 464 Australian birds, show that shifts in climatic niche space occur rapidly, and in multiple directions – not just poleward, as has been previously suggested. They suggest multi-directional shifts are related to both changes in temperature and precipitation patterns, and estimate that, if measured only in terms of poleward shifts, the fingerprint of climate change will be underestimated by an average of 26% in temperate regions of the continent, and 95% in tropical regions (VanDerWal et al. 2013).

Potential expansion of pests and disease

A further implication of the potential expansion of the tropical zone is the expansion of associated diseases and pests. Of particular concern has been the potential for an extension in the geographical range of vector-borne diseases such as malaria, dengue fever and Lyme's disease, as temperatures and precipitation patterns become more suitable for disease vectors including mosquitoes and ticks (Githeko et al. 2000; Kovats et al. 2001). In 2010 the Tropics region represented 96% of cases and 99% of deaths from malaria, and approximately 72% of dengue infections occur in the Tropics (State of the Tropics 2014), thus any expansion in the range of these diseases will have significant impacts. Githeko et al. (2000) propose that the greatest impact on transmission rates will occur at the extremes of the range at which transmission now occurs, suggesting an increase in occurrence in the subtropical regions bordering the tropical zone. Patz et al. (1998) modeled the potential spread of dengue carrying mosquitoes and conclude that endemic potential could increase by up to 47%

in regions already at risk, and that incidence may increase first in those regions which currently border endemic zones in either latitude or altitude. The greatest increase in the annual epidemic potential of dengue was forecast to occur in subtropical regions, including the southern United States, China and Northern Africa in the northern hemisphere, and South America, southern Africa, and most of Australia in the southern hemisphere.

In 2009, the evidence supporting actual changes in disease transmission rates and geographic range was limited, particularly in the case of malaria (e.g.: Hay et al 2002; Reiter 2005). At that time, many models were predicting an increase in occurrence and the range of disease vectors with increasing temperatures. However, since mosquitoes and ticks can desiccate easily and die under dry conditions (WHO 2003), regions predicted to become more arid as a result of tropical expansion may in fact be less at risk. Despite this, there was some evidence accumulating for an increase in the occurrence of tick-borne disease and dengue fever outside of the normal range - tick-borne encephalitis in Sweden had shown an increase in recent years and had been linked to milder temperatures (Lindgren and Gustafson 2001). Gatewood et al. (2009) also proposed that milder temperatures will result in more virulent strains of Lyme disease in North America while the World Health Organization recorded the extension of dengue fever into 15 new locations, including Hawaii, Nepal and Bhutan, in the period from 2000-2008.

More recent peer-reviewed studies reveal a stronger indication that disease vectors may be expanding their geographical range. For example, Lambrechts et al. (2010) state that the mosquito *Aedes albopictus* has dramatically expanded its geographic range over the past three decades, with implications for a variety of arthropod-borne viruses that it can carry, including dengue fever. There has also been a reemergence of dengue fever in Florida, since 2009 (Radke et al. 2012). There are also a number of studies which show an increase in range for tick species which carry Lyme disease. For example, the primary tick vector of Lyme disease in North America, *Ixodes scapularis*, has expanded

its range northward from the USA to colonise new regions in southern Canada; the authors state that this expansion is likely related to climatic warming (Leighton et al. 2012). Milder, shorter winters are also favouring the northern expansion of the white-footed mouse in Quebec, which is an important reservoir host for *Borrelia burgdorferi*, the pathogen responsible for Lyme disease (Roy-Dufresne et al. 2013). A similar picture has been found in Europe, where the range of the tick vector *Ixodes ricinus* is predicted to spread across northern Scandinavia, due to climate warming, and eventually encompass most of Sweden, Norway and Finland (Jaenson and Lindgren 2010).

Tonnag et al. (2010) have predicted a redistribution of malaria vectors in Africa based on climate change scenarios, with shifts in species boundaries expected southward and eastward. A recent study also provides evidence for an increase in the altitude of malaria distribution during warmer years in the highlands of Ethiopia and Columbia, implying that warming conditions could result in an increase of malaria in densely population highland regions of Africa and South America (Siraj et al. 2014).

Dengue hemorrhagic fever kills up to 12,000 people a year, mainly children, and the annual economic cost in the Americas and Asia of dengue fever is around US\$1.8 billion (Suaya et al. 2009). Githeko et al. (2000) propose that human settlement patterns in different regions will influence disease trends and that health risks will differ between countries that have developed health infrastructures and those that do not.

Conclusions and summary

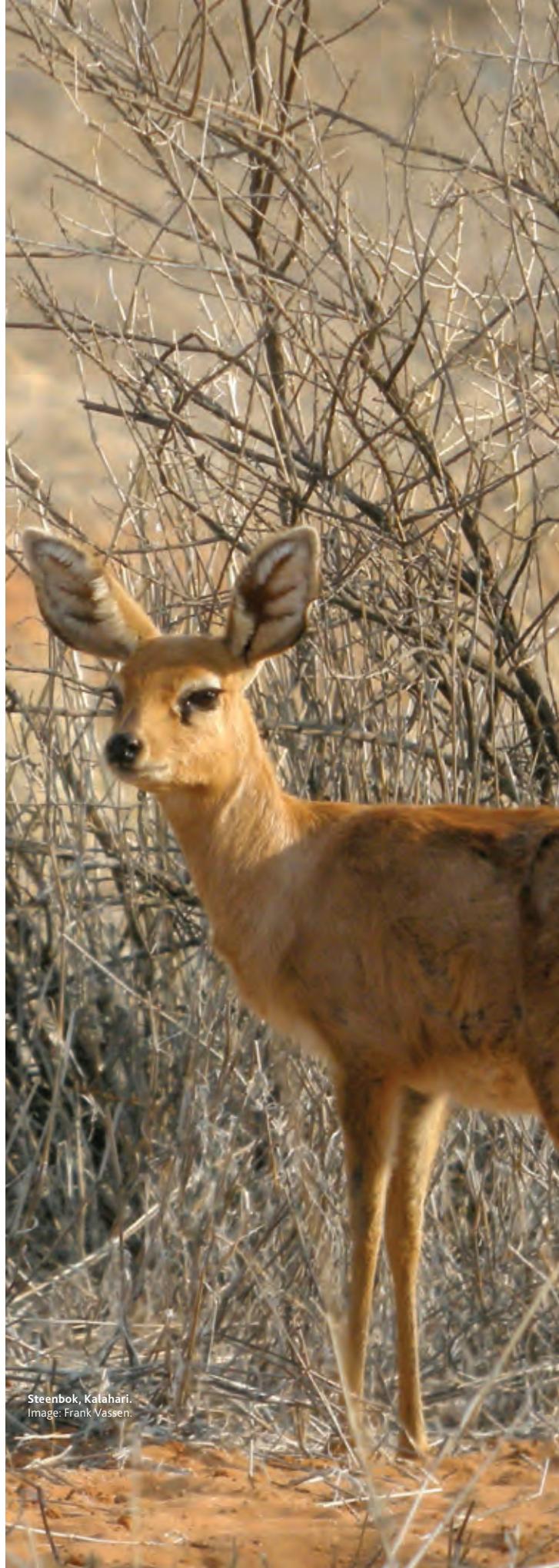
In 2009, we found there was accumulating evidence for the expansion of the tropical zone in both hemispheres. At that time, the Tropics were estimated to be expanding by between 222 to 533 km per 25 years, taken from studies we reviewed. In the five years since that report, evidence has continued to amass pointing to a tropical expansion, and more robust methodologies have been developed and critiqued. An estimate from

more than 30 studies now puts the rate of tropical expansion somewhere between 1.25 – 2.5°, or 138 – 277 km, per 25 years. Thus more recent studies tend to agree on a lower, but nonetheless significant, rate of expansion. However there is still disparity among estimates, most likely due to different methodologies used in estimates. In our earlier report, the drivers of the tropical expansion were very unclear, but recent research has identified that the primary drivers are likely to be greenhouse gases, black carbon, aerosols and other man-made pollutants, though this is expected to be an area of research that sees further developments in the near future.

The implications of a poleward tropical expansion are significant; subtropical arid, conditions may be seen in regions at higher latitudes which have historically enjoyed a more temperate climate, with implications for management of water resources and agricultural systems. However, some regions which currently border the equatorial zone may experience an increase in extreme rainfall, which could result in flooding, the displacement of communities and increased incidence of disease.

The poleward expansion of the Tropics appears to be linked to a concomitant expansion in the tracks of tropical cyclones, potentially bringing cyclonic activity to regions which have previously not experienced such weather events. Changes to the tracks and activity of cyclones, and other extreme weather events, will impact on human health, biodiversity and the economy. The burden of vector-borne diseases on health and the economy of the Tropics may also increase as more regions become climatically suitable for insect vectors.

The Tropics are the most biodiverse region on earth, with more endemic species and more biodiversity 'hotspots' than anywhere else. However research suggests that although many species are tracking climate changes, species in the Tropics may be lagging behind the rate of tropical expansion – meaning some species may not be able to sufficiently track their preferred environment and climate and may potentially risk extinction.



Steenbok, Kalahari.
Image: Frank Vassen.

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Mandalay.
Patrik M Loeff.



Mandalay.
Image: Dieter Zirnig.w

Appendices

Appendix A: Data sources for each indicator, including temporal coverage (in years) and additional notes regarding data coverage and limitations

The Ecosystem

Domain	Indicator	Data Source	Data coverage (years)	Notes
Atmosphere	Carbon dioxide emissions (CO ₂)	World Resources Institute's Climate Analysis Indicators Tool (CAIT). European Commission, Joint Research Centre (JRC)/PBL Netherlands Environmental Assessment Agency.	1950 - 2008	CO ₂ totals are emissions from fossil fuels and cement manufacture. The latest version of the dataset includes greenhouse gas data for 1990 to 2005 for most countries of the world.
	Greenhouse gas emissions (GHG)	World Resources Institute's Climate Analysis Indicators Tool (CAIT). European Commission, Joint Research Centre (JRC)/PBL Netherlands Environmental Assessment Agency.	1990 - 2005 for most countries of the world.	GHG emissions are a sum of data from individual sectoral emissions but it's important to note that GHG exclude emissions associated with land use, land-use change, the forestry sector due to high levels of data uncertainties. Missing nations include Somalia, Federated States of Micronesia, Hong Kong, New Caledonia, Puerto Rico, French Polynesia, Tuvalu, Macau and Timor Leste, Reunion, Palau.
	Energy supply from fossil fuels	Energy Information Administration – International Energy Statistics	1980 - 2010	Due to distribution networks of power supply, power supply was apportioned by population.
	Air pollution	World Bank Development Indicators For sub-national data for those countries that straddle the tropic / temperate divide data from the World Bank, (Development Economics Research Group Estimates) and WHO (Urban Outdoor Air Pollution Database)	1990 - 2010	At sub-national level for tropical straddlers is the PM ₁₀ concentration weighted by the proportion of city population relative to total population. For intervening years – data is year weighted between 1999 and 2008. Pre- & post- 1999 and 2008 data is used. For the non-tropical proportion of the straddlers, the national concentration is used.
Land and Water	Land degradation	World Soil Information	1981 - 2003	No degradation was noted for the following places, probably due to resolution of the data derived from satellite imagery: Fiji, French Polynesia, Hawaii, Kiribati, Marshall Islands, Micronesia, Palau, Samoa, Tonga, Tuvalu, Antigua & Barbuda, Barbados, Saint Kitts & Nevis, Saint Lucia, St Vincent & Grenadines, Maldives, Mauritius, Seychelles
	Agricultural land	Food and Agricultural Organisation of the United Nations – FAO Stat	1980 - 2009	There are no data for cattle and sheep/goat for American Samoa, British Virgin Islands, Cayman Islands, Cook Islands, French Guiana, Guadeloupe, Guam, Martinique, Montserrat, Netherlands Antilles, Niue, Reunion, United States Virgin Islands, Wallis and Futuna Islands
	Renewable water resources (RWR)	Food and Agricultural Organisation of the United Nations – Aquastat database	Long term average.	RWR data divided by population data. Straddling nations were calculated based on RWR by tropical population.

Domain	Indicator	Data Source	Data coverage (years)	Notes
Oceans	Wild marine catch	FAO – Fishstat	1950 - 2010	No data available for: Mayotte, Reunion, Anguilla, Aruba, British Virgin Islands, Caymans Islands, Grenada, Guadeloupe, Martinique, Montserrat, Netherlands Antilles, Turks and Caicos Is., US Virgin Islands, French Guiana, American Samoa, Cook Islands, Guam, Nauru, Niue, Northern Mariana Is., Tokelau, Wallis and Futuna Islands
	Aquaculture	FAO – Fishstat	1950 - 2010	Due to difficulties in discriminating data at sub-national levels to marine and inland waters, data are aggregated to total aquaculture only.
	Coral	Bryant et al. (1998); Burke et al (2011)	1998 & 2010	The data for 1998 Reefs at Risk and 2010 Reefs at Risk Revisited assessed integrated threat slightly differently. In the 2011 data set reefs assessed at very high risk were aggregated with reefs at high risk to allow direct comparison with 1998 data. Both assessed the integrated local threats to reefs from coastal development, marine-based pollution & damage, watershed-based pollution and overfishing or destructive fishing practices (eg cyanide, explosives). See the data source publications for more detail.
	Mangroves	Food & Agriculture Organisation (2007). The world's mangroves 1980-2005. FAO Forestry paper 153, Rome.	1980 - 2005	Nations excluded due to limited data availability: Wallis & Futuna Is, American Samoa, Aruba, Bahamas, Cayman Islands, Turks & Caicos Islands, US Virgin Islands, British Virgin Islands, Guam, Nauru, Niue, Northern Mariana Is, Tokelau, Mayotte, Guadeloupe, Martinique, Montserrat, Netherlands Antilles, French Guiana, Grenada. No mangroves in Hawaii according to Spalding (2010)
Biodiversity	Biodiversity & Threatened Species	International Union for the Conservation of Nature – Red List of Threatened Species 2012.2. International Union for the Conservation of Nature – Summary Statistics	2012	Regional data downloaded with straddlers dealt with at a national level. At the sub-national level for straddlers, efforts made to determine distribution from IUCN website or other relevant websites.
	Terrestrial & marine protected areas	United Nations – Millennium Development Goals. International Union for the Conservation of Nature, United Nations Environment Programme and the World Conservation Monitoring Centre – the World Database on Protected Areas	2012	Only designated areas were included (proposed & inscribed areas were excluded).
	Extent of primary forests	Food and Agricultural Organisation of the United Nations – Global Forest Resource Assessment 2010. Australia data from Australia's State of the Forests Report 2008. Bangladesh data from National Forest and Tree Resources Assessment 2005-2007.	1990 - 2010	The Russian Federation is excluded from the time series analysis because there was a large difference in the reported change rate (from +1.6 million hectares per year in the 1990s to -0.5 million hectares per year in the period 2000–2005) related to a modification to the classification system introduced in 1995 rather than actual changes in primary forest area.

Appendix A: Data sources for each indicator, including temporal coverage (in years) and additional notes regarding data coverage and limitations

The Human System

Domain	Indicator	Data Source	Data coverage (years)	Notes
Poverty	Population below \$1.25/day	World Bank – PovcalNet	1981 - 2008	No data are reported for Afghanistan. This approach was less successful when looking at the East Asia & Pacific region. This covers five UN sub-regions (Eastern Asia, South Eastern Asia, Melanesia, Micronesia and Polynesia), and probably reflects the heterogeneity of nations in this region. PovcalNet does not 'explicitly' report data for North Korea and Mongolia (UN Eastern Asia), Burma/Myanmar (UN South Eastern Asia), Solomon Islands and Vanuatu (UN Melanesia), Kiribati, Marshall Islands, Northern Mariana Islands, Palau and Samoa (UN Micronesia), and American Samoa and Tonga (UN Polynesia).
	Undernourished population	Food and Agriculture Organisation of the United Nations – Food Security Indicators	1990 - 2012	Insufficient data for the following nations: Equatorial Guinea, Mayotte, Reunion, Saint Helena, Anguilla, Aruba, British Virgin Islands, Cayman Islands, Grenada, Guadeloupe, Martinique, Montserrat, Netherlands Antilles, Turks and Caicos Islands, Virgin Islands (U.S.), American Samoa, Cook Islands, Guam, Midway Islands, Nauru, Niue, Northern Mariana Islands, Tokelau, Wake Island, Wallis and Futuna Islands, French Guiana, Singapore, Bhutan, Oman, Qatar
Urbanisation	Urban population	World Bank – World Development Indicators (UN, Department of Economic & Social Affairs, Population Division)	1980 - 2010	Of nations to be reported, this data set does not include data for Curacao, Kosovo, Serbia, St Martin, Western Sahara, Gibraltar, Vatican, Falkland Islands, Saint Pierre & Miquelon, Occupied Palestinian Territory
	Slum population	World Bank – World Development Indicators	2001, 2005	Data are reported for 2001 and 2005. No data available for: Curacao, Kosovo, Serbia, St. Martin, Western Sahara, Gibraltar, Holy See, Falkland Islands (Malvinas), Saint Pierre and Miquelon, Occupied Palestinian Territory (West Bank and Gaza)
Health	Life expectancy	United Nations – World Population Prospects	1950 - 2010	Of nations to be reported, this data set does not include data for: Seychelles, South Sudan, Antigua and Barbuda, Dominica, Saint Kitts and Nevis, Kiribati, Marshall Islands, Palau, Tuvalu
	Maternal mortality	Maternal Mortality Estimate Inter-Agency Group	1990 - 2010	Reported data on maternal and child mortality are limited as only one-third of nations have a complete civil registration system with good attribution of cause of death (WHO 2012b). Estimates are produced using a combination of civil registration and census data, and household surveys.
	Under-five mortality	United Nations – World Population Prospects	1950 - 2005	Reported data on maternal and child mortality are limited as only one-third of nations have a complete civil registration system with good attribution of cause of death (WHO 2012b). Estimates are produced using a combination of civil registration and census data, and household surveys.
	Obesity and Non-Communicable Diseases	World Health Organisation – Global Burden of Disease	2002 - 2010	Data not included for China (Hong Kong, Macao), Puerto Rico, Saint Kitts & Nevis, French Polynesia, New Caledonia, Western Sahara, Occupied Palestine Territory, Channel Islands, Isle of Man, Faeroe Islands, Gibraltar, Holy See, Montenegro, Bermuda, Falkland Islands, Greenland, Saint Pierre and Miquelon, Leichtenstein, Serbia, Seychelles, Antigua & Barbuda, Dominica, Kiribati, Marshall Islands, Palau, Tuvalu, Andorra, San Marino, Monaco.

Domain	Indicator	Data Source	Data coverage (years)	Notes
Health	HIV & AIDS	World Bank – World Development Indicators. World Health Organisation – Global Burden of Disease	1990 - 2010	Data are for population aged 15-49 years old. Based on nations for which the World Bank or WHO report data. By population, China is the largest nation for which data are unavailable. The following exclusions are made in the Tropics (expressed as a percentage of the 2010 regional population): 15% of Oceania (11 nations); 11% of Caribbean (6 nations); 22% of South East Asia (3 nations; less than 1% if China is not included); 13% of North Africa & Middle East (2 nations); and 9% of Central & Southern Africa (2 nations). Nations in the Rest of the World for which data were unavailable represent 40% of the population, with China, Russian Federation, Algeria, Uzbekistan, Iraq and Argentina accounted for the greatest proportion.
	Tuberculosis	World Health Organisation – TB burden estimates	1990 - 2010	TB burden estimates are calculated using models that consider the number of notifications, the estimated degree of underreporting, mortality data and trends in neighbouring nations. Population was used to estimate TB burdens at sub-national levels for nations that straddle the Tropics.
	Malaria	World Health Organisation – World Malaria Report 2012	2010	Proportion of cases in tropical zone within straddling countries derived from Cibulkis et al. (2011). Nations in the tropics that are excluded from analyses based on data availability: Mayotte, Reunion, Saint Helena, Anguilla, Aruba, British Virgin Islands, Cayman Islands, Grenada, Guadeloupe, Martinique, Montserrat, Netherlands Antilles, Turks and Caicos Islands, United States Virgin Islands, American Samoa, Cook Islands, Guam, Midway Islands, Nauru, Niue, Northern Mariana Islands, Tokelau, Wake Island, Wallis and Futuna Islands, French Guiana.
	Dengue and other neglected tropical diseases	Bhatt et al (2013) The global distribution and burden of Dengue. Center for Disease Control – Neglected Tropical Diseases. World Health Organisation – Global Burden of Disease	2010	There are no time series data for dengue. Data presented are for 2010. No data for Central & Southern Africa and Northern Africa & Middle East. Information presented are based on estimates by Bhatt et al (2013). Nations with no estimate data include Botswana, Namibia, Sao Tome and Principe, South Sudan, Hong Kong, Macau, Australia and USA.

Appendix A: Data sources for each indicator, including temporal coverage (in years) and additional notes regarding data coverage and limitations

The Human System

Domain	Indicator	Data Source	Data coverage (years)	Notes
Education	Mean years of schooling of adults	Barro and Lee (2010) Educational Attainment in the World 1950-2010	1980 - 2010	<p>Nations in the Tropics excluded from analysis: Angola, Burkina Faso, Cape Verde, Comoros, Equatorial Guinea, Ethiopia, Guinea, Guinea-Bissau, Madagascar, Nigeria, Sao Tome and Principe, Seychelles, Djibouti, Chad, Eritrea, Somalia, South Sudan, Timor-Leste, Antigua and Barbuda, Dominica, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, French Polynesia, Kiribati, Marshall Islands, Micronesia (Fed. States of), New Caledonia, Palau, Samoa, Solomon Islands, Tuvalu, Vanuatu. For straddling nations:</p> <ul style="list-style-type: none"> • No data at subnational level was located for Bangladesh - an assumption was made that MYS for Tropical and non-tropical Bangladesh are the same • Australia, China, India, Saudi Arabia and United States report data at subnational level by the highest level of education achieved.
	Youth literacy	United Nations Educational, Scientific and Cultural Organisation – Institute for Statistics Data Tables - Education	1980 - 2010	<p>Nations in the Tropics excluded from analysis: : Angola, Congo, Guinea-Bissau, Sierra Leone, Djibouti, Mali, Somalia, Timor-Leste, Antigua and Barbuda, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Belize, Suriname, French Polynesia, Kiribati, Marshall Islands, Micronesia, New Caledonia, Palau, Solomon Island,s Tonga and Tuvalu.</p>
	Adult literacy	United Nations Educational, Scientific and Cultural Organisation – Institute for Statistics Data Tables - Education	1980 - 2010	<p>UNESCO Adult (15+) Literacy dataset (1975-2011) is quite fragmented, particularly it does not have much data prior to 1995. For developed countries, for which data on literacy (in terms of literacy as it is defined by UNESCO) are not collected, an assumed 99% literacy rate was used in the data analysis.</p>
Work	Unemployment rate	International Labour Organisation – Global Employment Trends	2000 - 2011	<p>Nations in the Tropics excluded from analysis: : Sao Tome and Principe, Seychelles, Djibouti, South Sudan, Antigua and Barbuda, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, French Polynesia, Kiribati, Marshall Islands, Micronesia, New Caledonia, Palau, Samoa, Tonga, Tuvalu and Vanuatu.</p>
Economic Output	GDP per capita	World Bank – World Development Indicators	1980 - 2010	<p>In the World Bank dataset there are a number of nations for which data are not reported, and for a large number of countries, gaps in the times series. Nations that don't have 80% of their data points reported by the World Bank were excluded from the analysis (in the Tropics these countries include Zimbabwe, Somalia, Cuba, Puerto Rico, French Polynesia, Marshall Islands, New Caledonia, Tuvalu).</p>
Government	Public sector debt service burden	World Bank – World Development Indicators	1980 - 2010	<p>There are no data available for Oceania. The Caribbean only includes data for the Dominican Republic. Other large economies omitted from analysis due to data availability are Tanzania, Nigeria, Saudi Arabia, Hong Kong, and Singapore.</p>

Domain	Indicator	Data Source	Data coverage (years)	Notes
International Trade & Investment	Exports of goods and services (% of GDP)	World Bank – World Development Indicators	1980 - 2010	The following nations in the Tropics were excluded from analyses because no data were available: Mayotte, Reunion, Saint Helena, Anguilla, Aruba, British Virgin Islands, Cayman Islands, Grenada, Guadeloupe, Martinique, Montserrat, Netherlands Antilles, Turks and Caicos Islands, Virgin Islands (U.S.), American Samoa, Cook Islands, Guam, Midway Islands, Nauru, Niue, Northern Mariana Islands, Tokelau, Wake Island, Wallis and Futuna Islands, French Guiana
	Imports of goods and services (% of GDP)	World Bank – World Development Indicators	1980 - 2010	Nations in the Tropics excluded from analyses because no data available were as for 'Exports of goods and services (% of GDP)'
	Foreign direct investment, net inflows	World Bank – World Development Indicators	1980 - 2010	Nations in the Tropics excluded from analyses because no data available were as for 'Exports of goods and services (% of GDP)'
Science & Technology	Research and development (% of GDP)	World Bank – World Development Indicators	2000 - 2008	Data for this indicator are very poor. Data are particularly limited for nations in Africa, the Middle East, the Caribbean and Oceania.
	Tertiary Enrolments	United Nations Educational, Scientific and Cultural Organisation – Institute for Statistics Higher Education Statistics	1950 - 2010	Estimates do not include India, China or Hong Kong
	Scientific & technical journal articles	US National Science Federation – Science and Engineering Indicators	1990 - 2009	Nations in the Tropics excluded from analysis: Cape Verde, Comoros, South Sudan, Timor Leste, Antigua and Barbuda, Dominica, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and Grenadines, French Polynesia, Kiribati, New Caledonia, Tuvalu. Estimates from Hong Kong and Macao are reported as China.
Human Security	Refugees	World Bank – World Development Indicators	1990 - 2010	Nations omitted from the analysis include South Sudan, Marshall Islands, Micronesia (Fed States of) New Caledonia, Channel Islands, St Pierre & Miquelon, Isle of Man, Faeroe Islands, Gibraltar Holy See, Lichtenstein, Falkland Islands, Greenland, Occupied Palestinian Territory

Appendix A: Data sources for each indicator, including temporal coverage (in years) and additional notes regarding data coverage and limitations

The Human System

Domain	Indicator	Data Source	Data coverage (years)	Notes
Crime & Corruption	Homicide rate	World Bank – Criminal Justice Sources; World Bank – International Public Health Sources	2004	The analysis was restricted to the 2004 year due to the difficulty in sourcing time series data for most nations. Dataset does not include French Polynesia, New Caledonia, Tuvalu, Western Sahara, Occupied Palestine Territory, Channel Islands, and Montenegro.
	Corruption	World Bank – World Development Indicators	2006 - 2011	The analysis was restricted to the period from 2006 to 2011 inclusive due to the large data gaps in the years from 1995 to 2005, in the majority of the tropical regions. Nations excluded from analysis due to no data in Transparency International dataset include: Tropical Nations: Saint Kitts & Nevis, Antigua & Barbuda, South Sudan, Marshall Islands, Micronesia (Fed States of), New Caledonia, Palau, French Polynesia, Tuvalu, Rest of the World; Channel Islands, St Pierre & Miquelon, Isle of Man, Faeroe Islands, Gibraltar, Holy See, Liechtenstien, Falkland Islands, Greenland, Bermuda, Monaco, San Marino, Occupied Palestinian Territory, Andorra and Western Sahara.
Gender Equality	Ratio of female to male adults with at least secondary education	Barro and Lee (2010) Barro-Lee Educational Attainment Dataset	1950 - 2010	Nations excluded from analysis: Angola, Burkina Faso, Cape Verde, Comoros, Cote d'Ivoire, Equatorial Guinea, Ethiopia, Guinea, Guinea Bissau, Madagascar, Nigeria, Sao Tome and Principe, Seychelles, Djibouti, Chad, Eritrea, Somalia, South Sudan, Timor-Leste, Antigua and Barbuda, Dominica, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, French Polynesia, Kiribati, Marshall Islands, Micronesia (Fed. States of), New Caledonia, Palau, Samoa, Solomon Islands, Tuvalu, Vanuatu
	Women in national parliament	Inter-Parliamentary Union – Women in National Parliament Statistical Archive	1997 - 2011	Nations excluded from analysis: Mayotte, Reunion, Saint Helena, Anguilla, Aruba, British Virgin Islands, Cayman Islands, Grenada, Guadeloupe, Martinique,Montserrat, Netherlands Antilles, Turks and Caicos Islands, Virgin Islands (U.S.), American Samoa, Cook Islands, Guam, Midway Islands, Nauru, Niue, Northern Mariana Islands, Tokelau, Wake Island, Wallis and Futuna Islands, French Guiana

Domain	Indicator	Data Source	Data coverage (years)	Notes
Infrastructure	Gross capital formation (% of GDP)	World Bank – World Development Indicators	1980 - 2011	Nations excluded from analysis: Angola, Equatorial Guinea, Guinea, Liberia, Nigeria, Sao Tome and Principe, Seychelles, Tanzania, Djibouti, Eritrea, Niger, Somalia, South Sudan, Yemen, Maldives, Brunei Darussalam, Cambodia, Laos, Burma/Myanmar, Timor-Leste, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, El Salvador, Suriname, Kiribati, French Polynesia, Marshall Islands, Micronesia, New Caledonia, Palau, Samoa, Solomon Islands Tuvalu.
	Access to improved water source	United Nations Children's Fund/World Health Organisation Joint Monitoring Program	1990 - 2010	Nations excluded from analysis: Bahrain, Bermuda, Channel Islands, Faeroe Islands Isle of Man, Falkland Islands (Malvinas), Liechtenstein, Poland, San Marino, Western Sahara; and nations in the Tropics: Brunei Darussalam, China, Hong Kong SAR China, Macao SAR, New Caledonia, Puerto Rico, Saint Vincent and the Grenadines, Seychelles, South Sudan
	Access to improved sanitation	United Nations Children's Fund/World Health Organisation Joint Monitoring Program	1990 - 2010	Nations excluded from analysis: Bahrain, Bermuda, Channel Islands, Falkland Islands (Malvinas), Faeroe Islands, Gibraltar, Holy See, Isle of Man, Italy, Liechtenstein, New Zealand, Saint Pierre and Miquelon, Saudi Arabia, San Marino, Western Sahara; and nations in the Tropics: Brunei Darussalam, China, Hong Kong SAR China, Macao SAR, New Caledonia, Puerto Rico, Saint Vincent and the Grenadines, Saudi Arabia, Seychelles, South Sudan
Communication	Mobile phone subscriptions	International Telecommunications Union - Statistics	1993 - 2010	Nations excluded from analysis: Western Sahara, Channel Islands, Gibraltar, Holy See, Isle of Man, Falkland Islands (Malvinas), Saint Pierre and Miquelon. Nations excluded due to large number of missing data points: Macedonia, Serbia. Of nations to be reported with missing data points for which an assumption has been made that there were nil mobile cellular mobile subscribers in specific years: Antigua & Barbuda: 1993-1995, Democratic Republic of Congo: 1993-1994, Liechtenstein: 1993-1997, Palau: 1993-2001, Saint Kitts & Nevis: 1993-1995, Saint Lucia: 1993, Timor-Leste: 1993-2002, Occupied Palestinian Territory: 1995-1999. Of nations to be reported with a missing data point for which a mid point calculation has been used to calculate number of mobile cellular subscribers: Bahamas: 1994, Congo: 1997. Of nations to be reported with missing data points for which av. annual growth rate has been used to calculate number of mobile cellular subscribers: Sierra Leone: 2004-2006
	Fixed broadband internet subscribers	International Telecommunications Union - Statistics	2000 - 2010	Nations excluded from analysis: Western Sahara, Channel Islands, Gibraltar, Holy See, Isle of Man, Falkland Islands (Malvinas), Kosovo, Saint Pierre and Miquelon, South Sudan. Nations excluded due to large number of missing data points: FYR Macedonia, Montenegro, Occupied Palestinian Territory, Serbia and Turkmenistan. [also many nations for which assumption was made that data were nil for specific years]
	Internet users	International Telecommunications Union - Statistics	1993 - 2010	Nations excluded from analysis: Western Sahara, Channel Islands, Gibraltar, Holy See, Isle of Man, Falkland Islands (Malvinas), Kosovo, Saint Pierre and Miquelon, South Sudan. Nations excluded due to large number of missing data points: Liechtenstein, Macedonia, Monaco, Palau, Serbia

Appendix B – Nations of the Tropics

	Tropical population 2010 (millions)	% of population in the Tropics	% of Regional population in the Tropics
Central & Southern Africa			
Angola	19.55	100.0%	2.8%
Benin	9.51	100.0%	1.3%
Botswana	1.97	51.5%	0.2%
Burkina Faso	15.54	100.0%	2.4%
Burundi	9.23	100.0%	1.2%
Cameroon	20.62	100.0%	2.9%
Cape Verde	0.49	100.0%	0.1%
Central African Republic	4.35	100.0%	0.6%
Comoros	0.68	100.0%	0.1%
Congo, Democratic Republic of	62.19	100.0%	9.7%
Congo, Republic	4.11	100.0%	0.6%
Cote d'Ivoire	18.98	100.0%	2.9%
Equatorial Guinea	0.70	100.0%	0.1%
Ethiopia	87.10	100.0%	12.2%
Gabon	1.56	100.0%	0.2%
Gambia	1.68	100.0%	0.3%
Ghana	24.26	100.0%	3.6%
Guinea	10.88	100.0%	1.5%
Guinea-Bissau	1.59	100.0%	0.2%
Kenya	40.91	100.0%	5.9%
Liberia	3.96	100.0%	0.6%
Madagascar	21.08	91.8%	2.8%
Malawi	15.01	100.0%	2.2%
Mauritius	1.23	100.0%	0.2%
Mozambique*	23.97	80.3%	2.8%
Namibia*	2.18	80.3%	0.3%
Nigeria	159.71	100.0%	23.3%
Rwanda	10.84	100.0%	1.6%
Sao Tome & Principe	0.18	100.0%	0.0%
Seychelles	0.09	100.0%	0.0%
Sierra Leone	5.75	100.0%	0.9%
Tanzania	44.97	100.0%	6.6%
Togo	6.31	100.0%	0.9%
Uganda	33.99	100.0%	4.9%
Zambia	13.22	100.0%	1.9%
Zimbabwe	13.08	100.0%	1.8%

	Tropical population 2010 (millions)	% of Population in the Tropics	% of Regional population in the Tropics
North Africa & Middle East			
Djibouti	0.83	100.0%	0.6%
Chad	11.72	100.0%	7.3%
Eritrea	5.74	100.0%	3.4%
Mali*	13.99	99.9%	10.0%
Mauritania	3.61	99.3%	2.2%
Niger	15.89	100.0%	10.1%
Saudi Arabia*	11.16	41.3%	7.4%
Senegal	12.95	100.0%	8.1%
Somalia	9.64	100.0%	6.1%
South Sudan	9.94	100.0%	6.0%
Sudan	35.65	100.0%	22.4%
Yemen	22.76	100.0%	15.7%
Caribbean			
Antigua and Barbuda	0.09	100.0%	0.2%
Barbados	0.28	100.0%	0.7%
Cuba	11.28	100.0%	27.3%
Dominica	0.07	100.0%	0.2%
Dominican Republic	10.02	100.0%	24.0%
Haiti	9.90	100.0%	24.2%
Jamaica	2.74	100.0%	6.6%
Puerto Rico (United States)	3.71	100.0%	9.1%
Saint Kitts & Nevis	0.05	100.0%	0.1%
Saint Lucia	0.18	100.0%	0.4%
St Vincent & the Grenadines	0.11	100.0%	0.3%
Trinidad and Tobago	1.33	100.0%	3.2%

* These nations have large populations and area and straddle the Tropics. Sub-national calculations were used and these nations divided into tropical and non-tropical regions for the analyses. See Appendix C.

	Tropical population 2010 (millions)	% of Population in the Tropics	% of Regional population in the Tropics		Tropical population 2010 (millions)	% of Population in the Tropics	% of Regional population in the Tropics
Central America							
Belize	0.31	100.0%	0.2%		Brunei	0.40	100.0%
Costa Rica	4.67	100.0%	3.6%		Cambodia	14.36	100.0%
El Salvador	6.22	100.0%	4.7%		China*	161.39	7.9%
Guatemala	14.34	100.0%	11.0%		China – Hong Kong SAR	7.05	100.0%
Honduras	7.62	100.0%	5.8%		China – Macau SAR	0.53	100.0%
Mexico*	91.72	77.7%	67.5%		Indonesia	240.68	100.0%
Nicaragua	5.82	100.0%	4.4%		Laos	6.40	100.0%
Panama	3.68	100.0%	2.7%		Malaysia	28.28	100.0%
Oceania							
Australia*	1.27	5.7%	10.0%		Burma/Myanmar	51.93	90.8%
Fiji	0.86	100.0%	6.8%		Philippines	93.44	100.0%
French Polynesia	0.27	100.0%	2.2%		Singapore	5.08	100.0%
Kiribati	0.10	100.0%	0.8%		Thailand	66.40	100.0%
Marshall Islands	0.05	100.0%	0.4%		Timor-Leste	1.08	100.0%
Micronesia, Federated States of	0.10	100.0%	0.9%		Vietnam	89.05	100.0%
New Caledonia (France)	0.25	100.0%	2.0%				
Palau, Republic of	0.02	100.0%	0.2%		South America		
Papua New Guinea	6.86	100.0%	54.5%		Bolivia	10.16	100.0%
Samoa	0.19	100.0%	1.5%		Brazil*	167.18	82.4%
Solomon Islands	0.53	100.0%	4.3%		Colombia	46.44	100.0%
Tonga	0.10	100.0%	0.8%		Ecuador	15.00	100.0%
Tuvalu	0.01	100.0%	0.1%		Guyana	0.79	100.0%
United States (Hawaii)*	1.38	0.4%	10.8%		Peru	29.26	100.0%
Vanuatu	0.24	100.0%	1.9%		Suriname	0.52	100.0%
South Asia							
Bangladesh*	54.99	36.6%	7.4%		Venezuela	29.04	100.0%
India*	690.68	54.0%	89.7%				
Maldives	0.33	100.0%	0.0%				
Sri Lanka	20.76	100.0%	2.8%				

Appendix C – Sub-national regions/states/provinces used for large nations that straddle the Tropics

Australia		
Queensland	Western Australia	Northern Territory
<ul style="list-style-type: none"> • Central West • Far North • Fitzroy • Mackay • Northern • North West 	<ul style="list-style-type: none"> • Kimberley • Pilbara 	
Bangladesh		
Barisal	Chittagong	Kulna
Brazil		
Acre	Goias	Pernambuco
Alagoas	Maranho	Rio de Janeiro
Amapa	Mato Grosso	Rio Grande di Norte
Amazonas	Mato Grosso do Sul	Rondonia
Bahia	Minas Gerais	Roraima
Ceara	Para	Sao Paulo
Distrito Federal	Paraiba	Sergipe
Espirito Santo	Piaui	Tocantins
China		
Guangdong	Guangxi	Hainan
India		
Andaman & Nicobar Islands	Gujarat	Mizoram
Andhra Pradesh	Jharkhand	Orrisa
Chhattisgarh	Karnataka	Pondicherry
Dadra & Nagar Haveli	Kerala	Tamil Nadu
Damon	Lakshadweep	West Bengal
Dui	Madhya Pradesh	
Goa	Maharashtra	

Mexico		
Aguascalientes	Jalisco	Quintana Roo
Campeche	Mexico	San Luis Potosi
Chiapas	Michoacan	Tabasco
Colima	Morelos	Tlazcala
Federal District	Nayarit	Veracruz
Guanajuato	Oaxaca	Yucatan
Guerrero (Warrior)	Puebla	Zacatecas
Hidalgo (Noble)	Queretaro	
Saudi Arabia		
Asir	Jizan	Najran
Baha	Makkah	
United States		
Hawaii		



Palau.
Image: Lux Tonnerre.



STATE OF
THE TROPICS

2014 REPORT

Is life in the Tropics getting better?

The inaugural *State of the Tropics 2014 Report* addresses this nominally simple question. It provides the first in-depth, objective assessment of the Tropics as an environmental and geopolitical entity in its own right. Drawing on the knowledge, experience and diverse backgrounds of leading institutions across the Tropics the report assesses the state of the region and examines the implications of the immense changes the region is experiencing.

The assessment demonstrates that nations in the Tropics have made extraordinary progress across a wide range of environmental, social and economic indicators in recent decades. Rapid population and economic growth mean its influence is set to rise dramatically in coming decades.

The nature of this influence will depend on how the region addresses its many challenges, and whether it realises its potential and opportunities.

A defining feature of the Tropics is its extraordinary biological, cultural and socio-political diversity, yet its people are connected by an ability to survive and thrive in this diverse and dynamic region. *State of the Tropics* explores this diversity and the inextricable link between natural systems and human health, well-being and prosperity. It provides a basis from which to work towards a prosperous, sustainable and equitable future for the Tropics and will be a valuable resource for policy makers, geopolitical analysts, researchers, students and other stakeholders interested in the Tropics.

Participating institutions:

