

A Global Village

WHERE POLICY AND POLITICS MEET SCIENCE AND ENGINEERING



What does her world look like?



Planet Future of Climate Change Negotiation | Feeding 9 Billion



Atoms Quantum Computing | Nuclear Fusion



Internet Internet is Going Local | ELearning for Health Workers



People Global Health & Human Security | Sex Workers in India



Cities Healthy & Sustainable Cities | Urbanisation in Ghana



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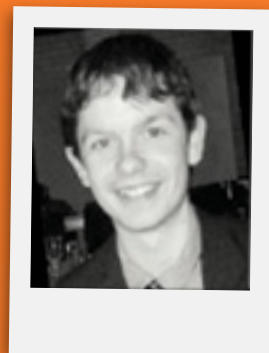
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THE UK IS SLIPPING DOWN THE WORLD EDUCATION RANKINGS FOR SCIENCE, AND IS NOW RANKED 16TH OUT OF 65 COUNTRIES

Foreword

2012 has barely begun, but there is little time to reflect on the turmoil of last year's remarkable events before preparing for the challenges ahead. In just a few months, seemingly unchallengeable Middle Eastern dictatorships were overthrown, and Europe was shaken by the uncertainties of the Euro crisis.

Not long after the first anniversary of the devastating earthquake in Haiti, Fukushima provided a sobering reminder that even rich and well prepared countries like Japan can still be humbled by Nature, with aftershocks for the nuclear industry felt as far away as Germany.

And media organisations, already stretched by falling advertising and the desperate search for a new model of sustainable financing, were hit by the high one-off editorial costs of covering 2011's events while – for some in the UK – questioning the ethics of news gathering with the ugly use of illegal phone tapping.

All that in a year when the global population reached 7bn, a sobering reminder of the underlying structural challenges for humanity in coping with rising urbanisation, tensions over food production and continued global warming – a trend for which the Durban summit that brought 2011 to an end offered scant reassurance.

Meanwhile, those studying and researching in British universities faced little protection from the harsh headwinds facing their colleagues elsewhere, with tuition fees rising, growing pressures on financial support and uncertain times for future employment.

But Imperial College is special, as this New Year edition of *A Global Village* testifies. It brings together some of the most remarkable people from around the world, reflecting the continued international lure of London and its focus beyond its own national and subject borders.

A welcome interdisciplinary focus is reflected in articles on a wide range of topics, whether the co-existence of prostitution alongside India's rapid recent growth; the limits of lacto-vegetarianism in reducing food and energy waste; or the strains triggered up by a growing role for private, patented agricultural research in developing countries.

Technology and engineering, as befits Imperial's roots, are underlying themes offering great potential, reflected in examples cited of the internet's value in eLearning and apps for better informing consumers. Combining the best technical knowledge with a deep understanding of its social consequences across different subjects and borders would not be a bad resolution for the coming year.

Andrew Jack

Pharmaceuticals Correspondent with the Financial Times based in London



Note from the Editor

At the opening of 2012, the future seems particularly uncertain. The past 12 months have been a period of continued turbulence in financial markets – with seemingly more doom and gloom on the horizon – and sustained environmental and political instability around the world. In parallel, the Information Age is on warp speed; Twitter has turned from tool to trial and Facebook chronicles our lives. With life so rapidly changing, how can we begin to contemplate 2050?

We know this much: 9 billion people will inhabit the planet in 2050, and not only will they need to be fed and sheltered, but we are likely to face unstable climatic change, an uncertain energy landscape, and a widening divide between those who have, and those who have not. With these issues in mind, our contributors cast a shrewd eye into that murky crystal ball.

On the environmental front, *David Fisk* argues that, as efforts to stem climate change heat up in the next decade, the single track UN system is liable to cave under pressure unless parallel forums are established for consensus building. On the question of food, *Colin Thirtle* contends that without increased investment in R&D, our ability our ability to meet food demand in the future will be compromised, and this will be exacerbated by the rise of intellectual property issues in biotech.

How will we power ourselves in 2050? *Greg Offer* suggests that a range of technologies will be used to generate electricity, which in turn will power the massive surge in demand for cars. Nuclear fusion is touted by *Philip de Grouchy & Arthur Turrell* as a possible ‘panacea’ for future energy needs, with 2012 being the year of possible breakthrough.

Attached to your Mac? This Editor would not be surprised if rehab and retreats for Internet addiction become the norm in years to come – she already periodically orchestrates escapes to connectivity free zones as a basic survival tool. As communication via digital devices increasingly underlies every activity – both at work and at play – *Herbert Wiklickly* muses that quantum physics may help us develop secure encryption systems. *Katarina Reinhardt* tells us about an innovative scheme that enables health workers in the developing world expand their skills via eLearning, and *Calypso Montouchet* examines the responsibility of the media and the pharmaceutical industry in engaging patients online with clinical research.

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Neave

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DISCLAIMER

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Moving beyond the United Nations

The Future of Global Climate Change Negotiation

Prof. David Fisk, Imperial College London

The UN Climate Change Treaty staggered to its next stage, if only just, at the Durban Conference of Parties in early December 2011. But what was new? The Treaty has been up to the trick of brinkmanship with a touch of fudge for almost twenty years. It is not the negotiators fault but the inherently dysfunctional Treaty system. Setting in train some parallel platforms, both national as well as international, is well overdue. The emerging and unavoidable need to handle decisions on adaption may be one such opportunity. The object is not to replace the Treaty system but take off some of the intense pressure for delivery. One advantage of multiple processes is that it would no longer be in the interests of the enemies of global agreement to push the Treaty system to self-destruct.

It is 6 am on the 18th floor of the UN Building in New York. We – the small group of negotiators who form the 'Friends of the Chair' – have just been handed the 'Chair's text'. It will be put to the climate treaty negotiators in two hours time on a 'take it or leave it' basis. We have only reached agreement as a drafting group because someone was so tired that they have made a mistake. But despite the adrenaline that keeps our eyelids open, we are all so tired from arguing non-stop for 30 hours that we have no idea who made the mistake. That was the text of the Framework Convention on Climate Change in 1992. Those who have followed the fraught course of the Conference of Parties meeting in Durban last month will realise that little changes.

We have only reached agreement as a drafting group because someone was so tired that they have made a mistake ... That was the text of the Framework Convention on Climate Change in 1992

There is a reason for all this drama. While teaching my Masters Course, students were invited to negotiate just a small amendment to the Kyoto Protocol that addressed adding aircraft emissions. The UN Text they inherited was already replete with 'square brackets'. In negotiating texts disputed language is square bracketed. Ideally negotiations involve trading-off language in one bracket against language in another. Being Imperial College, no one needed to role-play. We had a native US, EU and G77 developing country groups. It is an interesting experiment. Students who had worked together brilliantly on case studies, adding insights from many different backgrounds, were now at each other's throats within

30 minutes. Some square brackets were resolved, but more were added. Three hours later they were no farther than they had been when they started. Instead of issuing a Chair's text we

called it a day. There is something a touch dysfunctional in an environmental negotiation!

No Binding Glue

Most international treaties seek to codify what is an emerging pattern of behaviour. Not all States of the UN are expected to be signatories. The Treaty provides a platform for common behaviour and a destination for those not yet ready to join. We would never have had a World Trade Organisation if everyone had to be a free trader from day one. The Law of the Sea took a decade to negotiate, and then had to wait for the minimum of 60 countries to ratify it in their respective legislatures before it came into force. That was a further 12 years.

The US Congress, apparently mindful of its War of Independence, is seldom minded to ratify treaties that give majority voting powers to other States, even if the US complies more frequently than many others with treaty provisions. The 1992 Framework Convention's ratification was the exception that only proves the point. It got through on a Tuesday afternoon with only 11 Senators present.

This snail's pace is all because the UN is not a world government; it is a way of the world governing itself. Upward legitimacy is by definition slow if consensual, and is used only because downward authority would be undeliverable or unenforceable at global scale. The early environmental treaties surprised everyone in the UN by their apparent swiftness. Now older and wiser commentators know better.

So there we were in the early dawn, all looking at the operative part of the text, checking that the commas that we have moved to and fro have stayed where we agreed, loosening a qualification here and tightening another one there. All, that is, except India's chief negotiator sitting on my immediate right. What is he doing, looking at the text at the back, procedural stuff agreed months ago? He tells me it is his rule. Always double-check the clause on the procedure for leaving the convention. Eighteen

months notice it turns out. Canada as it happens has just left the Convention's one and only Protocol without much ado. Yet the media, lobbyists and, at times, the UK Government, have been going on about the necessity of a binding commitment? It was apparently the outstanding point that delayed Durban so long. What is the game?

Domestic ratification of a convention usually creates domestic law, so a clear commitment creates clear law. But international

law is otherwise not binding. How else could Saddam Hussein and Colonel Gadaffi have signed the Rio Declaration on Environment and Development in 1992? The International Whaling Convention has to steer clear of a proposition that would simply see all those who kill whales leave it. Even a domestic law is only operatively binding while it is on the statute book and someone is accountable for enforcement. There is nothing wrong with writing a law that looks as if it commits the citizens of countries to do something. What is wrong is others acting as if it had actually done so.

Carbon Tourism

A lack of 'binding' glue is not the only systemic problem with UN Treaties. Constructing an international agreement inside the UN system necessarily entails a great

Square brackets abound in one draft text circulated prior to the 2009 Copenhagen Conference of the Parties

Chair's Proposed Draft Text on the Outcome of the Work of the Ad Hoc Working Group on Long Term Cooperative Action under the Convention

Version 11/12/09
08:30 am

Enhanced action on the provision of financial resources and investment

Decides

40. To [establish] [define] an [X] body, which shall [work under the [guidance [and authority] of and] be accountable to the Conference of the Parties, [to implement the policies, programme priorities and eligibility criteria of the financial mechanism], pursuant to decision --/CP.15 (Finance);

41. Option 1: [To establish, under the financial mechanism, [a] fund[s] as an operating entity pursuant to Article 11 of the Convention with specialized funding windows;

Option 2: [To establish [, through the [X] body,] [Y] fund with specialized funding windows under the financial mechanism;

42. That the Conference of the Parties shall enter into an arrangement with the [Z], serving as an operating entity of the [fund with specialized funding windows] in accordance with Article 11, paragraph 3, of the Convention;

deal of historical baggage. The terms ‘Developed’ and ‘Developing’ countries from the 1960’s are now clearly just meaningless. Climate Change inherited this model in the form of Annex 1 countries that at the time represented OECD membership. All kinds of countries, have since joined the OECD but have not volunteered to join Annex I.

The targets, whenever they are agreed, are set on national consumptions without any allowance for exports or imports. Hence Qatar, formally a developing country, has one of the highest emissions per capita as a result of processing gas for others like the UK to use. Natural gas liquefied onshore in the UK incurs a 20-30% emissions penalty, but the quarter of UK natural gas that arrives as LNG does not. Singapore incurs a similar overhead from refining, and we need not even mention that proportion of Chinese emissions that reflect its role as the rest of the world’s workshop. The lack of concern that the current Treaty structure might simply incentivise ‘carbon tourism’ in the manufacture of traded products is always surprising.

Indeed the idea of setting global goals and then sharing them out amongst Parties is masochistic, choosing the mountaineering route of steepest ascent. It is easy to agree a global objective when you can later rescind from it if you are unhappy with your share of the burden of meeting it. Even if negotiators could be restrained from trying to win for the sake of it, their home states differ culturally in what would be considered the principles of ‘fair’ or ‘equitable’. An attempt to use markets for permits as an alternative allocation regime has proved an extraordinary failure. It has left green investment bankrupt and smoke stacks still smoking. So there the world is back to square one.

The UN Treaty: A Teetering Tower Easily Toppled?

These shortcomings are easier to see standing outside the UN system than from within. The more the UN system is tempted to climb up in front of everyone else, the more likely it is to fall. The collateral damage of such a failure is all the greater if the UN has positioned itself as the exclusive forum for collaborative action. It was the threat of the calamity of ‘no agreement’, rather than the

threat of climate change itself, that got the final text at Durban through two sleepless days after the negotiations were planned to finish. But the risk of the Treaty system falling into the abyss still remains and plays easily into contrarian hands eager to give it that extra push. But why would the UN system be the only forum for such a calamitous global issue? Are there no new platforms for moving forward?

The emerging new platform is adaptation. This was at one time never mentioned because it conferred credence to a rather ugly ‘sit back and let them eat cake’ thesis promoted by those who would use their cash from selling fossil fuels to insulate themselves from a changing climate. But now, with higher values of climate sensitivity to greenhouse gas concentrations more likely, those who need to plan for adaption are creating a new perspective. At its core is a critical local issue that has to be addressed whether there is a UN or not.

Whatever is agreed or not agreed in Treaties, money will still need to be spent on adjusting existing infrastructure – soft and hard – to new climate conditions. ‘Hope for the Best, Plan for the Worst’ might be the UK Environment Agency’s new motto when considering flood defences. Trying to get international agreement on abatements, when ‘damage’ was still only in computer model graphics, may have been worth the punt. But such early precautionary action is seldom realised in environment policy. It is not that precaution is not a natural human characteristic, it is just that without seeing ‘dead in the streets’ we find it hard to agree collectively on what to select to be precautionary about. So the adaption platform is going to be open for business.

Taxing the Brown to Give to the Green

HM Treasury’s Climate Change Strategy once asserted that there was no implication for public finances from climate change. It is easy to see why they had to say it, but objectively it is hardly a credible assessment of the ‘greatest threat to mankind’. The same inconsistency occurs in IPCC projections, where climate woe and catastrophe has no apparent effect on economic growth rates! Recent flooding in Asia and Australia has shown this separation not to be the case. But who should raise the funds to repair damage that will be soon, if not is already, uninsurable? Will not future taxpayers believe that this is less a burden to be born socially but rather,

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as with US Superfund to clean up hazardous waste sites in the 1970's, a levy whose income source needed to be more focused as a matter of sheer politics?

It would be just speculation to guess how this parallel agenda would play out in different legislatures, but why not a national carbon levy on emissions as a plausible front runner? After all, Australians have given themselves both a tax to repair recent extreme weather damage and a carbon-trading scheme. Why didn't they just co-join them and increase political legitimacy? Since this kind of levy is a local taxation that cannot wait for international harmonisation it would have to apply to imports and exports of both fossil fuels and embodied energy. The WTO has even been kind enough to provide

The UK Climate Change Committee ruled out recommending carbon 'border duties', on the rather implausible grounds that it would make WTO negotiations more complex

the rules by which to carry it out, but not everyone sees this as a possibility. The UK Climate Change Committee ruled out recommending carbon 'border duties', on the rather implausible grounds that it would make WTO negotiations more complex – as if that were possible!

Away from UN-ery altogether there is another emerging platform where decision-takers look at the treaties from outside and not within. Faced with a world where local needs for funding adaption are looking for a deep pocket, industrial technology strategists may not feel they can take the risk of assuming that because negotiations falter their markets won't still slip away from fossil fuel intensive products. The ups and downs of climate negotiations might then be second order. It is not as if the fossil fuel energy security

Becoming too big for its boots? The UN Building looms large in NYC





Negotiations are increasing fraught as pressure mounts to come to a binding agreement on climate change

situation *sans climat* was working out at all comfortably, or that cash imbalances from current energy markets played no small part in present, and future, financial crises. There is a crisis looming in energy markets across the board that technology strategists have probably already spotted. So it may be then that the real clues to the future energy landscape are behind closed doors hiding the titles of corporate research contracts.

The Durban text has a focus on 2015 for key decisions, a choice co-inciding with the end of the Millennium Development Goals, which has been defended as a year of the perfect political storm to force decisive action. That may

be true, but using the same eerily appropriate metaphor even more bad weather seems likely to be piling in from other platforms. If it were not for the implied acute discomfort, it should be welcomed, because parallel actions promise to ease the UN process rather than dilute it. Even UN negotiators deserve some sleep.

Prof. David Fisk was Chief Scientist in the Department of the Environment and led the UK climate change negotiating team from 1992 – 1998. He now works in Systems Engineering in the Civil and Environmental Engineering Department at Imperial College London.

Agricultural R&D, Technology And Productivity to Feed 9 Billion by 2050

Prof. Colin Thirtle, Imperial College London

For much of 2008, soaring food commodities prices were a major news item. Rising prices are the market's signal that supply is not keeping pace with demand, so the events of 2008 have led to a reappraisal of the world's ability to feed itself. Food prices attracted attention to agriculture and agricultural science, which had been neglected during the preceding decades of plenty.

World population is expected to grow by one third (from 7 to 9.1 billion) and, allowing for increased income and changes in diet, global demand for food, feed and fibre is expected to grow by about 60% by 2050. Can the planet produce enough to meet these demands?

The answer is a qualified yes, but that does not mean that hunger will be banished. Producing enough food does not mean that it can be distributed in such a way that all 9.1 billion will eat adequately. Further significant obstacles to continued progress in agricultural production include lack of the right investment into research on increasing yields, adverse environmental conditions and climate change, the growth of patenting of robust engineered crop varieties, and the rise of biofuels.

At a global level, since the Second World War food output increased faster than population and income growth and demand, so that the long term trend in food prices has been downward. This resulted from the application of science to agriculture on the

biological side, first in the developed countries. Then, partly due to considerable public sector interest, transmission to less developed countries was followed with the success of the green revolution in Asia.

Even so hunger remains widespread, affecting some 925 million people who lack sufficient major macronutrients (carbohydrates, fats and protein). Another billion suffer a debilitating lack of important micronutrients (such as vitamins and minerals). At the other

end of the scale, a billion people eat too much, resulting in obesity, type II diabetes and cardiovascular disease.

As world population and global demand for food grow, how can we address these imbalances? What

are the opportunities and obstacles for innovation in developing efficient food production and distribution networks?

Taking R&D for Granted

In the developed countries agricultural R&D generates new technologies at experimental stations and extension services transmit them to farmers. This process is only as good as the weakest link: better educated farmers screen and adapt technologies better, so that all of these components play a role in adoption that leads to increased productivity.

Population will not outrun food production, in the manner predicted by Thomas Malthus. Like most other doomsayers he did not take technological change into account, but we are now taking it for granted at our peril

Region	Expenditures [million 2000 international \$]			Share [%]	
	Public	Private	Total	Public	Private
LDCs	12,819	862	13,682	93.7	6.3
DCs	10,191	12,086	22,277	45.7	54.3
Total	23,010	12,948	35,958	64.0	36.0

Estimated global public and private agricultural R&D (circa 2000). Source: Pardey et al. 2006

Historically, the majority of biological technologies, like new plant varieties, were developed by public sector institutions and were available to any less developed countries that could adapt them to suit their own soils and climate. Thus, the breakthroughs in basic science were passed on to the countries with less scientific capacity and high yielding, fertiliser responsive plant varieties spread across Asia.

India embarked on this process in the early 1960s and doubled yields (output per hectare) in the following 25 years. This was just as well, as that is how long it took for India's population to double. If this process continues, population will not outrun food production, in the manner predicted by Thomas Malthus. Like most other doomsayers he did not take technological change into account, but we are now taking it for granted at our peril.

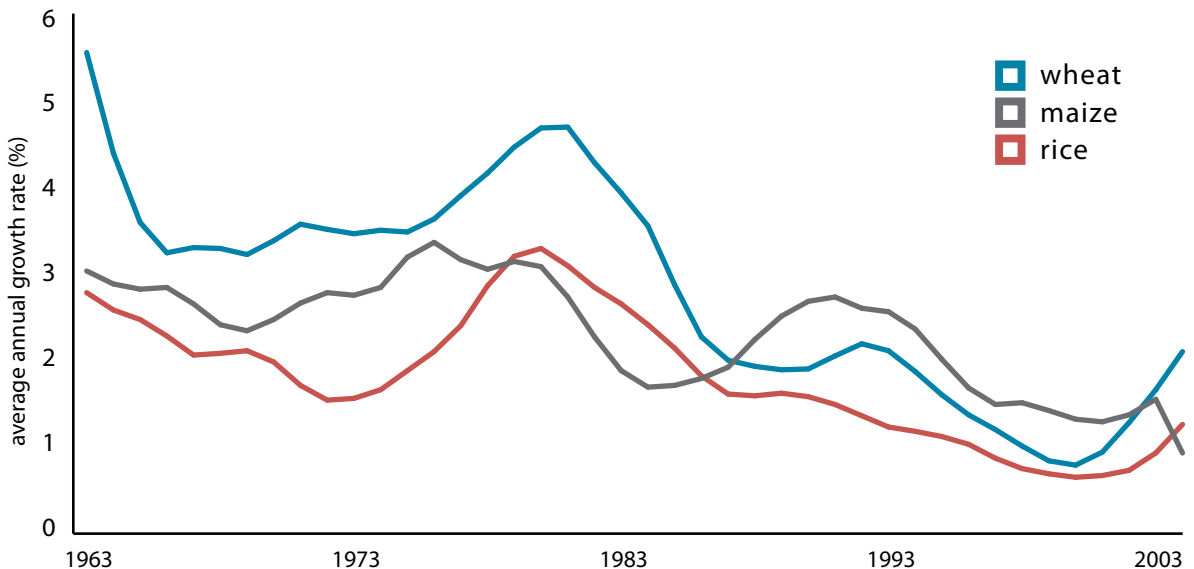
As Ye Sow, So Shall Ye Reap ... and Eat

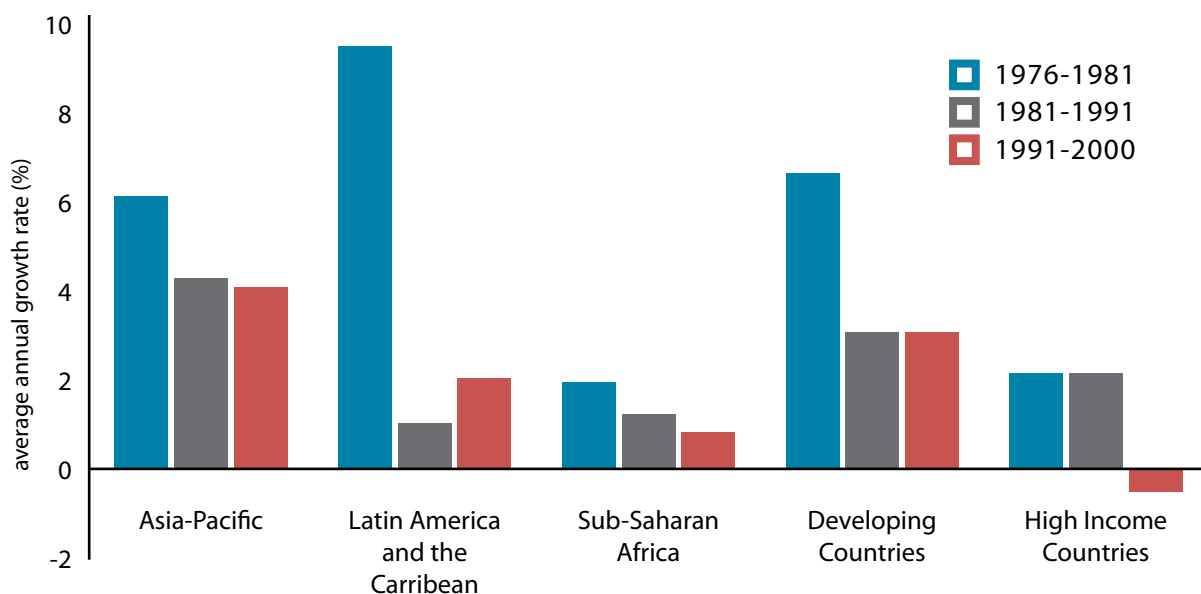
Rates of increasing yields, however, are at risk. Investments in agricultural R&D across the world have

been successful on aggregate and have produced high rates of return, but the level of spending has not been maintained. From the 1970s onwards, public expenditures have been growing less fast and in the high income countries fell from \$10.534 billion to \$10.191 billion in the 1990s. This fall is minor, but R&D was also retargeted towards public interest areas such as the environment and food safety, so the allocation to productivity enhancing research declined far more.

The old adage says, as ye sow, so shall ye reap. For the most important cereal crops the growth rates in the developing countries were 3% or better at the height of the green revolution in the early 1980s. Since then growth rates have fallen so that by 2000, the rates for rice and wheat were about 1% and maize a little better at around 1.5%. There seems to have been a slight recovery since 2000, which is surely needed as these growth rates are less than population growth and per capita food availability would be falling.

Growth rates of yields for major cereals in developing countries are slowing. Source: World Bank Development Report 2008





Growth rates in public sector agricultural R&D spending. Source: Pardey et al. 2006

Getting Food to the Hungry

Obviously estimates with such a long time span are imprecise but the amounts can be roughly calculated. The current output growth rate is 0.53% per annum and this needs to be raised to 1.55% to meet demand by 2020. To do this agricultural R&D investment in the developing country national agricultural research systems (NARS), and in the network of public bodies associated with World Bank, may need to double from \$5 billion per annum to \$10 billion. If the investments are allocated to maximise output, the impact of seven years of doubled R&D (\$35 billion total) is a 1% increase in output by 2020 and a reduction of 203 million in the number of people in \$1 per day poverty.

The bulk of the increased R&D is allocated to East, Southeast and South Asia, which have the highest payoffs. If poverty reduction is the target, much more is allocated to Sub-Saharan Africa (SSA) and South Asia and by 2020 output is increased by only 0.58%, but the number of people taken out of \$1 per day poverty is 282 million. In SSA 144 million would be taken out of \$1 per day poverty, practically halving the poverty rate, from 48% to 25%. For South Asia, the equivalent figure is 124 million, with the poverty rate reduced from 35% to 26%. If these targets could be met, the costs may fall somewhat after 2020, as demand is expected to grow less rapidly.

The scientific revolution in agriculture is in danger of sinking into the mire of rent seeking, with the growth potential snuffed out

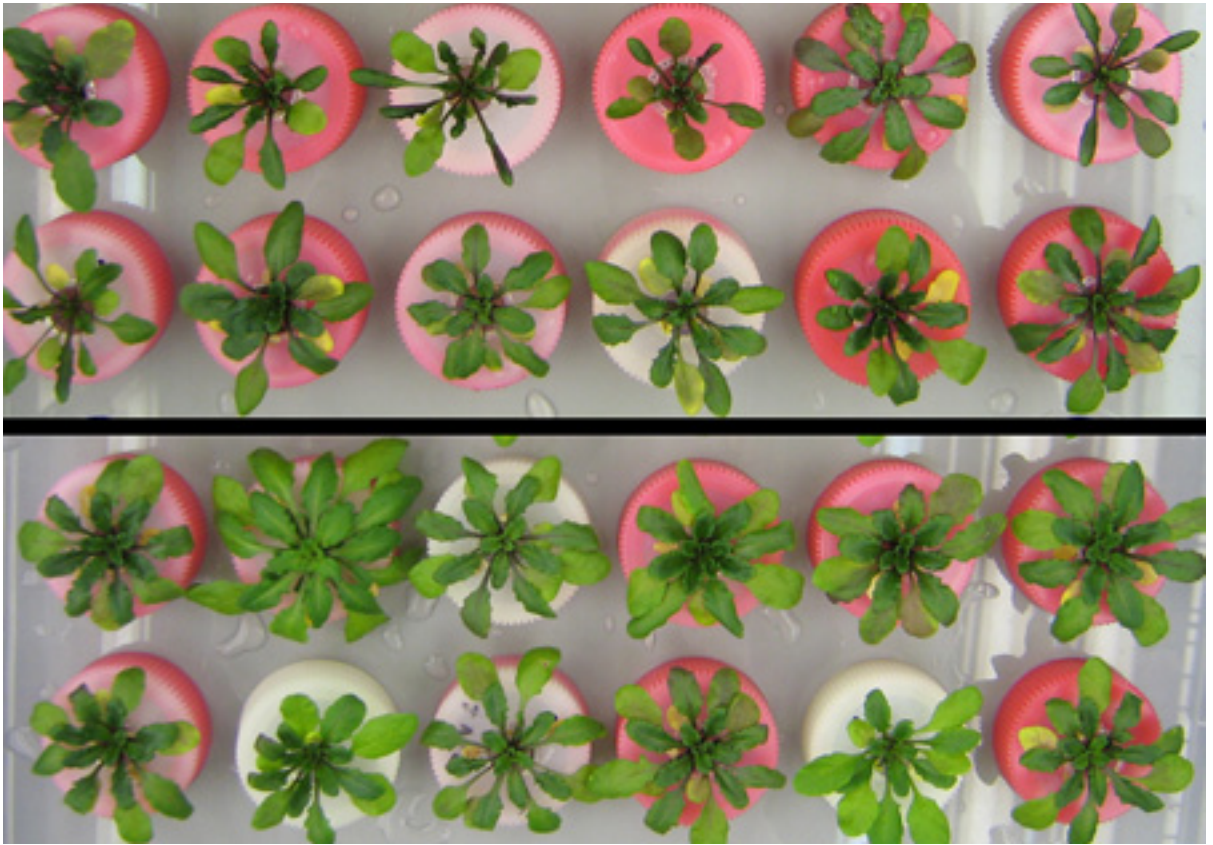
Thus, the scientists predict that there need not be a world-wide shortage of food and mass starvation, but producing enough and ensuring that it is distributed in such a way that hunger is eradicated is not the same thing. Getting sufficient food to the poorest people is a far more difficult problem. For this to happen, the poor need to gain entitlement to sufficient supplies of food. Here, expert opinion is more varied, but there is a consensus that while Asia has turned the corner and per capita incomes are growing, SSA is unlikely to follow this successful path.

For the urban poor, rising incomes can provide access to imported food, but for the rural poor it seems unlikely that there is an

answer. The increasing rural population will neither be able to grow enough themselves to be self sufficient, nor earn sufficient incomes to make up the deficit. This is perhaps the biggest challenge facing the world, but there are other complications.

Changing Climates

In the past few years, energy prices have risen dramatically and there is unlikely to be a return to cheap oil. Indeed, all the commodities used in industrialisation will tend to increase in price when India and China, which



Crop biotechnology can be used to promote the growth of plants in adverse environments. Non-GM plants struggle to grow in saline conditions (above) while GM plants thrive in the same conditions (below) at the University of Adelaide.

account for over 40% of the world's population, resume their building booms and rapid growth. For agriculture, expensive oil and gas means expensive fertiliser, yet increased fertiliser use was the leading cause of yield growth. Labour productivity grows with mechanisation, which again is fuel intensive. Water use is already unsustainable, and reduction of emissions is required to reduce global warming. So, we need new technologies that are energy and water saving at the same time as being cleaner.

Global warming is already taking effect, and in the poorest counties the effects are negative. Weather has been more variable and droughts and floods more common. SSA will mostly become hotter and drier and humanitarian disasters will continue and become more common. In this situation, protecting natural resources is essential.

Soil erosion and loss of fertility, waste of water and food losses in storage must all be addressed. More efficient natural resource use can improve productivity. For instance, drip irrigation uses scarce water very parsimoniously and is labour intensive, which suits poor areas with high unemployment.

Much is expected of a Gates and Buffet funded initiative in which Monsanto and BASF, major biotechnology companies, are providing the biotechnology, in collaboration with CIMMYT (the conventional plant breeding) and several NARS (trials and extension to farmers), to develop water efficient maize for Africa. The expectation is that, by 2020, the project will lead to two million extra tons of grain, better feeding 14-21 million poor people. As climate change increases the incidence of drought, the gains from such research and investment will clearly increase further.

Piessie J. & Thirtle C. (2010) Agricultural Investment, Extension, Research and Development. *Philosophical Transactions of the Royal Society of London – Series B: Biological Sciences*. **365**(1554): 3035-3047.

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Patenting Plants

Some aspects of biotechnology are already in use. Herbicide tolerant genetically modified (GM) maize was developed in the USA to save on expensive labour, but with

some ingenuity it is now preventing erosion in KwaZulu Natal (a province of South Africa), where white maize is being used with “planting without ploughing”. It is both high yielding and prevents soil erosion. GM maize has also been shown to have less carcinogenic toxins and insect resistance, with *Bacillus thuringiensis* (Bt) modified cotton also doing well in South Africa.

The driving force behind this GM revolution is the huge multinational companies, in this case Monsanto is the dominant player – it is responsible for 39 of the 54 GM events that have been approved for commercial use. The great majority of these involve Bt or herbicide tolerant (or both) soy, maize or cotton. Technically, the development of genetic markers played a key role in moving the public private boundary as they allowed the identification of specific traits in biological material that was not previously possible. Hence, patenting became more prevalent and the courts pushed the process forward with decisions in its favour.

In the rich countries, private R&D is now greater than that of the public sector – this is one of the biggest changes of the last few decades. The table shows that over 90% of less developed country (LDC) R&D is public, whereas most developed country (DC) research is now private. 20 years ago universities and public labs in the DCs did all the basic and strategic research that created a global commons of intellectual property (IP). Now the multinationals lead and the NARS and the international public system try to follow.

Thus, a consequence of extending patents to plants, in combination with the huge costs of biotechnology research, is that the NARS, whose size led to their ascendancy over small private seed companies in the last century, are losing ground to massive multinationals. Biotechnological discoveries and enabling technologies are patented and since genetic improvement is a derivative process, each incremental improvement adds a further layer of IP constraints. Mergers increase a company’s IP portfolio, giving it more freedom to operate and hence an advantage over smaller rivals. The building

blocks and the tools all come with IP constraints and are commercially useful only to companies with portfolios covering most inputs. For example, Golden Rice – developed as a fortified food to be grown in areas where there is a shortage of dietary vitamin A – required forty patents and six material transfer agreements.

Thus, the scientific revolution in agriculture is in danger of sinking into the mire of rent seeking, with the growth potential snuffed out. The common property in agricultural technology, which fed the NARS in poorer countries is becoming a thing of the past. This will make growth harder to maintain. IP may have killed the goose that laid the golden egg.

Biotechnological discoveries and enabling technologies are patented and since genetic improvement is a derivative process, each incremental improvement adds a further layer of IP constraints

Plants into Fuels

A final spectre lurking in the background is the most drastic change in agriculture since man first started keeping animals and planting crops. After decades of falling prices, a new market for agricultural output developed when the US decided to reduce its dependence on oil. The current forecast is that as much as 40% of the US maize crop may be used to

produce bioethanol, which is added to gasoline. So now, agriculture not only reacts to the oil price because of fertiliser, fuel and transport costs on the input side, but also due to the energy industry’s demand for its output.

With oil prices at around \$100 per barrel, this will not go away and agriculture has become a minor part of the massive energy industry. This is both a threat and an opportunity. Farmers need no longer worry about falling prices if all surpluses can be diverted to the energy industry. Indeed, agricultural output can expand as fast as possible to meet the bottomless demand for energy. But the threat to food security is very real in a world where filling gas guzzling vehicles in the USA will surely take precedence over feeding the rural poor in SSA. Hopefully world leaders are becoming more aware of the global and interconnected nature of food and energy problems.

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What Will Be on Your Plate in 2050?

Katherine Portilla, Imperial College London

You may have heard the term ‘carbon footprint’, but do you know your ‘food footprint’? Food consumption accounts for 30% of carbon emissions in the UK¹. This beefy figure includes growing, producing, and importing all of our grub, not forgetting emissions resulting from deforestation and land-use. What steps can we take as individuals to mitigate these issues?

There is a need to be more aware of the consequences of what and how we eat. Simple changes in diet, produce selection and storage will make a difference¹. On a broader scale, increasing farming productivity and efficiency are equally important. By acknowledging and acting on these issues now, we are determining the future ability of our planet to feed our children, and their children to come.

How can we reduce the impact of the food we consume? The link between food consumption and the environment is far from subtle. There are various ways to quantitatively determine the impact of food on the environment, where energy, transport, ecology and water must all be considered. A generalised quantitative measure of this impact is known as a ‘footprint’.

A carbon footprint refers to the emissions from a product, using a life cycle analysis from farm to fork. Transport is an important consideration for this measure. A similar calculation may be carried out on the total amount of water that is required to produce a food. An ecological footprint is a measure of the use of bio-productive space in hectares.

An understanding of these footprints will enable us to make more informed decisions about what we eat, and how we shop and store food.

Muddled Footprints

The carbon footprint accounts for how food is grown, manufactured and transported. It is measured in terms of volume of carbon dioxide emissions. Food transport is largely linked to the globalisation of trade and the increase in consumption of processed and packaged foods. Studies² show that processed food tend to be more resource-intensive to produce.

Rising incomes, urbanisation, an increasing need for convenience in food preparation, and the demand for variety have promoted the role of food-processing industries, which has also increased the importance of packaging. In addition, globalisation and decreasing transport costs have led to an increase in food transportation around the world, involving different modes of transport. Although the life span of perishable products has been prolonged, in response to this increase in distance from

What’s healthy for the planet is generally healthy for people too

- [1] WWF UK (2011) *Food: Changing the way we live*. [Online] Available at: <http://www.wwf.org.uk/what_we_do/changing_the_way_we_live/food> [Accessed 31 October 2011]
- [2] Lundqvist J., Fraiture C. & Molden D. (2008) *Saving Water: From Field to Fork – Curbing Losses and Wastage in the Food Chain*. Stockholm International Water Institute.
- [3] Hoekstra A. Y. (2011) The water footprint of food. University of Twente. [Online] Available at: <<http://doc.utwente.nl/77216/1/Hoekstra08waterfootprintFood.pdf>> [Accessed 10 December 2011]
- [4] Foley J. A. (2011) Can We Feed the World & Sustain the Planet? *Scientific American*. 305(5): 60-65.
- [5] Pimentel D. & Pimentel M. (2003) Sustainability of meat-based and plant-based diets and the environment. *American Journal of Clinical Nutrition*. 78(3): 660-663.
- [6] Collins A. & Fairchild R. (2007) Sustainable Food Consumption at a Sub-national Level: An Ecological Footprint, Nutritional and Economic Analysis. *Journal of Environmental Policy & Planning*. 9: 5-30.

sites of production to where food is marketed, a significant amount of food is still thrown away before it is even sold. This is partly due to an increasing concern about food safety and demand for high quality fresh produce. Thus, produce is often discarded even though it is still perfectly fit for consumption.

The water footprint concept is a geographically explicit indicator that shows volumes of water use and pollution, as defined by experts³. All countries import and export water in the form of agricultural commodities, where most developed nations have a net import. As a result, Europe's water security strongly depends on external resources. Furthermore, countries like the UK are essentially outsourcing water over-use to importing countries that can least afford to take on this burden.

As the global water demand for food production increases, it is important to promote innovation in the food sector in terms of water-sustainability. By investing in water saving technology, water conservation measures and wastewater treatment, the adverse environmental and social consequences of high water usage in food production may be reduced and compensated for³.

Let Them Eat ... Veg

The impact of livestock on the environment is a

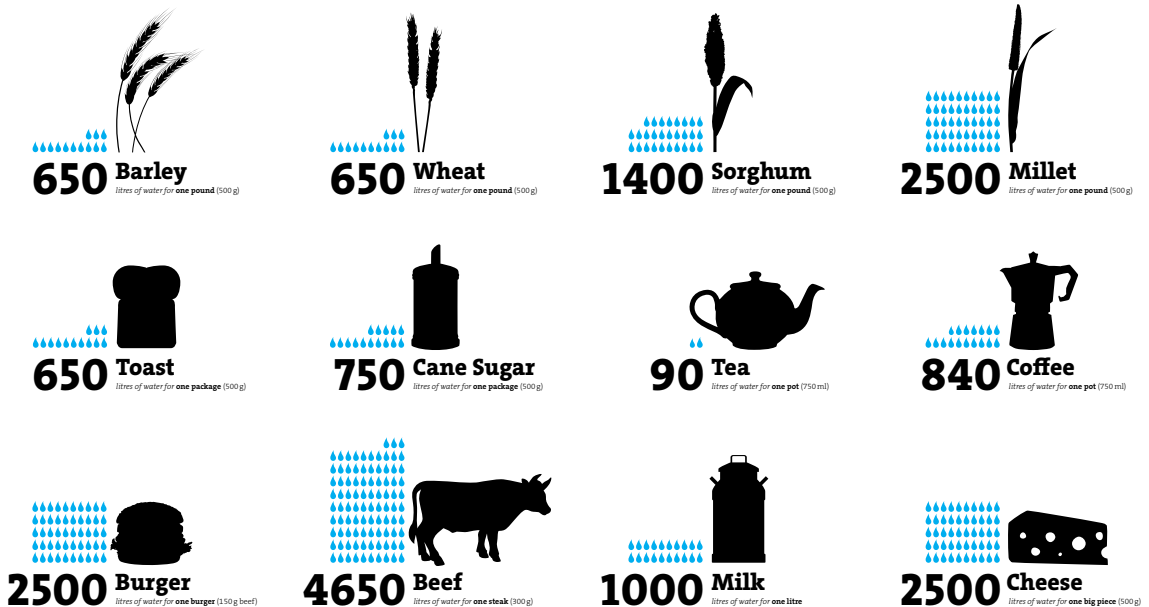
The water footprint of a product is the volume of freshwater used to produce the product, measured at the place where the product was actually made - i.e. the amount of the water used in the various steps of the production chain. One drop is equivalent to 50 litres of virtual water. (Source: The Virtual Water Project)

controversial topic. Its discussion tends to quickly transform into a debate of meat-eating versus vegetarianism, however a better approach would be that of sustainable versus unsustainable choices.

Why is meat one of the most environmentally unfriendly of all food groups? The simple answer is that livestock are accountable for approximately a fifth of CO² emissions on a global scale. However, as usual, things are more complicated.

Meat based diets are largely inefficient. Typically, 30 kg of grain are used to produce 1 kg of grain-fed beef, where roughly 35% of the world's crops are currently used for livestock feed⁵. Beef also has one of the largest global average water footprints with 15,500 litres per kilogram, in comparison to 250 litres per kilogram for potatoes³.

Technology, innovation, and production efficiencies are key to reducing the impact of livestock on the environment; however the question of consumption remains unanswered. Although livestock products and fish are important for a nutritious diet, in many countries their consumption is significantly higher than what is required for human health². To put it simply, what's healthy for the planet is generally healthy for people too. A study published in the American Journal of Clinical Nutrition



found that a meat-based food system requires more energy, land and water resources than a lactovegetarian diet⁵. The American Heart Association confirms that a lactovegetarian diet enables individuals to meet basic nutritional and calorific needs.

However, a lactovegetarian diet would not necessarily be the best solution to the issue of sustainability given that dairy products, particularly cheese and milk, have been found to have surprisingly high footprints^{5,6}. Cheese actually results in more emissions than a number of other meats and fish foods. This gives a lactovegetarian diet the potential to have just as high an impact on the environment as a meat-based one.

The WWF¹ suggests that a balanced diet, with more focus on the consumption of fruits and vegetables, as opposed to meat and dairy, would prove beneficial for both health and environmental issues. Nutritionists recommend the consumption of nuts and seeds, soy products, and legumes among other foods to meet recommended protein amounts, without consuming meat or dairy products⁷.

More Food from Less Land

The impact of food production with respect to land leads to the measure of an ecological footprint. We farm roughly 38% of the earth's land surface, making agriculture the predominant human use of land⁴. Studies⁴ show that agriculture has caused an extensive amount of damage to the environment; it destroys habitats, uses up freshwater, pollutes rivers and oceans and emits

greenhouse gases. Experts⁴ strongly recommend slowing and ultimately stopping the expansion of agricultural land, particularly for more sensitive ecosystems.

Increasing the productivity and overall efficiency of farms, by aiming for higher crop output per unit of water, fertilizer and energy, driven by research and innovation will be key to producing more food on less land. A culture of food consumption that rewards farmers for investing in sustainable methods could also reduce emissions and ensure that the rural economy thrives.

Waste Not, Want Not

Waste is a serious issue in food production, where studies⁴ claim that roughly 30% of the food produced on the planet is discarded, lost, or consumed by pests – there are huge losses incurred from field to fork². There is a dramatic difference between the net available food for consumption and the initial, edible crop harvest.

Waste tends to take place at the consumer end of the system in wealthy, developed countries. In this case, solutions include simple changes in daily consumption patterns such as the reduction of oversized portions and food thrown in the garbage. Losses in poorer countries are similar in size but occur at the producer end in the form of failed crops, stockpiles ruined by pests, as well as other reasons including bad infrastructure.

Researchers⁴ suggest that improved storage, refrigeration and distribution systems could cut waste significantly. A cell-phone system in Africa that links suppliers, traders and purchasers has seen notable results, and serves as an indicator of the potential that better market tools hold in this context. The complete elimination of waste may not be realistic, however targeted efforts, especially on the most resource-intensive foods, could make the crucial difference.

What Can We Do?

"Eat food. Not too much. Mostly plants."

American Food Writer Michael Pollan, 2008

When considering food production on such a large scale, changing what we consume could realistically cut greenhouse gas emissions and limit damage to vulnerable species and environments. Apart from a diet balanced for health and environmental reasons, various other life style changes can make a difference.

Roughly 30% of the food produced on the planet is discarded, lost, or consumed by pests

[7] Posch L. (2011) How to Get Complete Protein In Vegetarian. [Online] Available at: <<http://www.savvyvegetarian.com/articles/get-enough-protein-veg-diet.php>> [Accessed 13 December 2011]

[8] WWF UK (2011) *Think about what you eat*. [Online] Available at: <http://www.wwf.org.uk/how_you_can_help/change_how_you_live/think_about_what_you_eat> [Accessed 13 December 2011]

[9] Gerbens-Leenes W. & Nonhebel S. (2005) Food and land use: The influence of consumption patterns on the use of agricultural resources. *Appetite*. 45: 24-31.

[10] WWF (2011) A Square Meal. [Online] Available at: <http://www.wwf.org.uk/wwf_articles.cfm?unewsid=5236> [Accessed 19 November 2011]

[11] WWF (2011) Livewell Report 2011. [Online] Available at: <http://assets.wwf.org.uk/downloads/livewell_report_jan11.pdf>

[12] Tech TUC (2011) 5 iPhone Apps that Help you Reduce Your Carbon Footprint. [Online] Available at: <<http://techtuc.com/apple/5-iphone-apps-that-help-you-reduce-your-carbon-footprint>> [Accessed 13 December 2011]

[13] WWF Footprint Calculator [Online] Available at: <<http://footprint.wwf.org.uk>> [Accessed 13 December 2011]



Low-carbon options are beginning to appear on fast-food menus

Buying seasonal produce is often tastier, cheaper and is also better for the environment. Experts⁸ also suggest that cooking from scratch with seasonal ingredients can also be healthier. Farmers' markets allow customers to enjoy fresh, seasonally grown food that is often produced in the area. An added benefit of these establishments is that more capital remains in the consumers' community.

However, there are cases in which buying imported fresh produce can make more sense than buying locally. For example, it might be a more efficient use of energy and other resources to buy tomatoes in the winter that have been grown in natural sunlight in a southern country, as opposed to buying tomatoes grown in artificially heated greenhouses in Britain. This example illustrates how the issue of 'food miles' can be rather misleading, where the impact of transportation may only play a minor part.

Organics are positive in this context as they help reduce reliance on fossil fuel-based fertilisers and pesticides, as well as sustain local biodiversity. However, organic produce is not always an affordable solution. Additional suggestions made by the WWF⁹ include the purchasing of certified produce, such as Fairtrade or Rainforest Alliance.

Even the most conscientious shopper often has a hard time distinguishing comprehensively environmentally friendly fare

Complex Calculations

Bombarded with offers, slogans, certification and labelling, even the most conscientious shopper often has a hard time distinguishing comprehensively environmentally friendly fare. While food labels such as 'local' and 'organic' are popular among food suppliers, they do not tell us all that much about what we consume. Experts¹⁰ have suggested a new system of certification that awards points based on how well food delivers nutrition, food security, and other public benefits, minus their environmental and social costs, represented visually via the Livewell plate¹¹.

A smartphone application called the Good Guide, which offers a similar solution, has already shown significant success on the market¹². It is a free download that lets the user browse and search more than 70,000 entries for safe, healthy and sustainable products to purchase. In addition, various websites, such as the WWF¹³, exist which offer the use of a carbon footprint calculator that calculates the resultant emissions from the food you eat. Many of these models also offer personalised and practical solutions to reduce the footprint of one's diet. The popularity of these resources would imply that people have a growing interest in being aware of the energy, transport and water cost of the food they consume.

Feeding the Future

The relationship between food consumption, health, agriculture, and the environment is complex. However, this does not mean that solutions to issues including carbon emissions, waste, water security, etc. should be perceived as intangible. Changes in what and how we eat on an individual basis, such as decreasing our reliance on meat, has potential to make a real difference via a combined effort.

Today, various resources offer a means of attaining more information on the sustainability of produce, such as phone apps and web-calculators. On a larger scale, there is a need for radical changes in the food production and farming industry to ensure that emission reduction targets are met and bio-security is respected.

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The Future Energy Mix

Dr. Gregory Offer, Imperial College London

Society's use of energy underpins everything we do. We can't eat, work, travel, drink, wash, surf the Internet or do almost anything without consuming energy, and most of that energy currently comes from fossil fuels. Transport in particular is heavily dependent upon fossil fuels with currently no alternatives deployed at scale capable of replacing them. However, we need to replace them: fuel is becoming more expensive every year, and even big oil companies are predicting difficult times ahead.

The report *Signals & Signposts*, published by Shell last year, predicts a future described by two extremes: scramble and blueprints. These can be broadly interpreted as everyone working in their own interests versus everyone working together. They also predict a period over the next few decades, called the zone of uncertainty, during which there is huge shortfall in global energy supply compared to currently predicted future energy demand. In their own words, this can be either a zone of extraordinary opportunity, or extraordinary misery, but is more likely to be the latter if everyone works in their own interests.

The other argument for reducing our dependence upon fossil fuels should be well known by everybody by now; that burning them produces greenhouse gases which are driving climate change, and that the consequences of that climate change will, on the whole,

be very negative. However, the recent UNFCCC negotiations at Durban ended with little or no meaningful agreements, suggesting that we are a long way from an international agreement on how to manage a transition away from burning fossil fuels.

The problem currently appears intractable: even if we maximise our use of all existing energy resources – something that any agreement on climate change would surely restrict – energy companies are still predicting a large damaging energy gap between supply and demand. In addition, for many governments it seems that the economic and energy security arguments appear more real and more immediate, and that any agreement on climate change could make those problems worse. It is apparent that until climate change, economic development and energy security are dealt with together and consistently, it will be very difficult to counter the economic and energy security arguments for doing nothing about climate change.

The problem currently appears intractable: even if we maximise our use of all existing energy resources ... energy companies are still predicting a large damaging energy gap between supply and demand.

The UK is in a fortunate position, in that it has already done some of this work. The Department of Energy & Climate Change's 2050 Pathways Project last year calculated whether and how the UK could meet its commitment to reduce its greenhouse gas emissions by 80% by 2050. The answer was that the UK could, and there were multiple pathways, but all required a significant increase in effort compared to current policies at the time. However, although the UK is an island, we are part of the global village, and the UK cannot act alone. A global

[1] Kramer, G. J. & Haigh M. (2009) *Nature*. 462: 568-569.

energy crisis or runaway global climate change will affect every country, thus prompting Shell to frame their perspective with two extremes. One sees us work together as a global community to reinvent our economies and take advantage of new energy sources and technologies, and the other sees us compete with each other for dwindling resources down a 'business as usual' dead end.

Electricity as a Universal Energy Carrier

Generating the energy in the first place is critical, and it is possible to predict relatively accurately which technologies will be important in 2050. This is because the important thing is scale, and it takes a long time to reach scale. According to Kramer and Haigh¹ it takes 30 years to scale up new technologies from pilot plant to making a meaningful contribution, 1-2%, to global energy supply, and then a few more years to establish economic competitiveness at scale.

This means the technologies being developed now are those that will be important in 2050, such as wind, solar PV, solar thermal, new nuclear, biofuels, and marine. Others may be important in the long run, such as fusion, but only those that are already being demonstrated are likely to have reached scale by 2050.

Options for Transport

Electrification of transport is probably the most important alternative. We can produce electricity from anything, wind, solar, tides and waves, nuclear, and fossil fuels, and because of this electricity is considered as a universal energy carrier. Even with current electricity generation, based upon natural gas, electric vehicles would reduce emissions by roughly 40% if charged at the correct time. Moving to electricity from renewable sources, zero emissions are possible in the future. Most importantly, there are no limits to the expansion of electricity production.

Chemical fuels will still be important, and in 2050 we will still be able to produce considerable amounts of fossil fuels, but alternatives such as biofuels, solar fuel and hydrogen could all become major players. Biofuels are likely to be cheap to produce, and although second and third generation biofuels based upon crop wastes or salt water agriculture minimise competition with food production, land availability will always impose a natural limit on production. Solar fuels could be important, converting carbon dioxide and water directly into fuels using solar energy.

Electrification of transport is probably the most important alternative

Fuel cells could also be important, currently powered by hydrogen they are already commercially viable in some niches, such as forklift trucks in distribution centres. They are scheduled to emerge on the mass market in 2015 with major players such as Toyota and Daimler all planning major launches. Hydrogen production could initially limit their market penetration, but in the future they are likely to be more fuel flexible, and could ultimately occupy significant niches where electrification is challenging, for example heavy vehicles and long distances. As costs come down they could even challenge the dominance of the internal combustion engine with their higher efficiency.

Aviation and shipping are likely to consume most if not all of the chemical fuels we can produce, so an astute observer will still ask how cars will be powered. Again, the answer is electrification. Many have already recognised this, for example China has between 120-140 million electric vehicles, mostly scooters, and wants to make a million electric cars a year by 2015, while investing over a 100 billion Yuan over the next ten years. Likely triggered by concerns about air quality in cities, electrification of vehicles in China is becoming increasingly attractive for economic and energy security reasons, as it should for many other countries too.

Challenges and Opportunities

The only certainty is that things will change, and with that change there will be both challenges and opportunities. The challenge for some will be how to sustain their standard of living during a time of competition for resources and energy, for others it might just be how to sustain themselves at all. Alternatively, the opportunity will be to reinvent our society around sustainable energy sources with the potential to deliver improvements in quality of life for everyone and within the boundary conditions imposed by nature. As scientists and engineers this should be our goal, nothing less.

Dr. Gregory Offer is an EPSRC career acceleration fellow at Imperial College London. Greg conducts research into sustainable fuel production and sustainable transport, including electric, hybrid electric and fuel cell vehicles, and spent part of last year on secondment at the UK's Department of Energy & Climate Change working on the 2050 Pathways Project.

Fusion 2012: A Community Holds Its Breath

Philip de Grouchy & Arthur Turrell, Imperial College London

December 2011 saw the publication of the Department of Energy and Climate Change's latest roadmap to a decarbonised Britain. *The Carbon Plan* sets out a raft of future technologies, implemented on a grand scale, aimed at realising aspirations of an 80% UK emissions cut by 2050. Ultimately it is low carbon electricity that will enable the deepest cuts, opening the door to greener industry and transportation. The contribution of nuclear fission, Carbon Capture and Storage (CCS) and renewable technologies to this mix are discussed in detail, but nuclear fusion as a sustainable energy source is notable only by its absence. Is nuclear fusion a realistic prospect for energy generation in the coming decades?

2012 sees the final year of the three-year *National Ignition Campaign* (NIC) at California's Lawrence Livermore National Laboratory. This project has brought fusion technology closer than ever before to achieving so-called 'burn' – the elusive net production of energy from a sustained fusion reaction. With fusion showing so much promise as a low carbon technology, why does it persistently fail to make it onto the agenda of policy-makers?

For over 50 years, there has been a dream – some would say a fantasy – of achieving fusion on Earth. The rewards are irresistible – a zero emissions source of energy which could sustain humanity for thousands, if not millions, of years. But is this sort of hyperbole justified? Is nuclear fusion really a panacea for all our energy problems?

What makes fusion so attractive is that it releases enormous amounts of energy from every gram of Deuterium fuel – and there are 33 grams of it in every ton of seawater. Only the annihilation of matter and anti-matter releases more energy per kilo than a fusion reaction – it really is the ultimate energy resource.

Furthermore, fusion also avoids many of the major safety issues associated with nuclear fission: reactions terminate instantly on malfunction, as they must be continuously fuelled, and produce only small volumes of low-level radioactive waste.

Researchers, however, have not yet achieved 'breakeven' – the net production of energy coming from a sustained fusion reaction needed for commercial exploitation of the technology. As the NIC programme enters its final year, hopes are high that breakeven energy production levels will be exceeded, and fusion technology will finally move towards contributing to green energy consumption.

The Power of Seawater

All fusion reactions involve the combination of two small atoms (usually hydrogen) to make a single daughter atom. This may be contrasted to conventional nuclear fission in which a single parent nucleus splits into two smaller atoms. In both cases the atom or atoms at the end of the reaction are smaller and the difference in mass (and hence the energy, $E=mc^2$) can be turned into electricity.

The fusion process scientists are currently trying to replicate in the lab involves isotopes of hydrogen – deuterium (D) and tritium (T). If these are raised to high enough temperatures to overcome their electrostatic repulsion

The rewards are irresistible – a zero emissions source of energy which could sustain humanity for thousands, if not millions, of years

- NIC** National Ignition Campaign: Research project on ignition from California's Lawrence Livermore National Laboratory
- NIF** National Ignition Facility: Large laser-based ICF research device at the Lawrence Livermore National Laboratory
- ICF** Inertial Confinement Fusion: Process where fusion reactions are initiated by heating and compressing a fuel target
- MCF** Magnetic Confinement Fusion: Approach to generating fusion power that uses magnetic fields to confine the hot fusion fuel in the form of a plasma
- JET** Joint European Torus: Largest magnetic confinement plasma physics experiment worldwide; purpose to open the way to future nuclear fusion experimental tokamak reactors such as ITER and DEMO
- ITER** International Thermonuclear Experimental Reactor: International nuclear fusion research and engineering project; currently building the world's largest and most advanced experimental tokamak nuclear fusion reactor (Cadarache, France)
- DEMO** DEMOnstration Power Plant: Proposed nuclear fusion power plant intended to build upon the ITER experimental nuclear fusion reactor
- MagLIF** Magnetic Liner Inertial Fusion: Process exploiting both magnetic and inertial confinement in a device called Z-pinch
- LIFE** Laser Inertial Fusion Energy: Advanced fusion energy concept that builds on the technology developed at NIF to develop safe, clean, sustainable energy

and fuse, a fast moving Helium nucleus is released along with a high-energy neutron. The He nucleus passes on some of its energy to the rest of the fuel, triggering further fusion reactions – the fuel begins to 'burn'. The highly energetic particles released heat a coolant and electricity can be generated from steam in the conventional way.

The Quest for Burn

The challenge of fusion is initiating this burn wave. Only at densities of around 100 times that of lead and temperatures six times hotter than in the core of the sun will fusion fuel ignite. Here matter is in its fourth state – plasma – an electrically charged, light emitting fluid. Containing this super heated material is the unenviable task of fusion scientists. No known material will hold

it – instead the fluid must be suspended in a vacuum by high magnetic fields (1,000s of times more powerful than the Earth's), a process likened to confining a jelly with elastic bands.

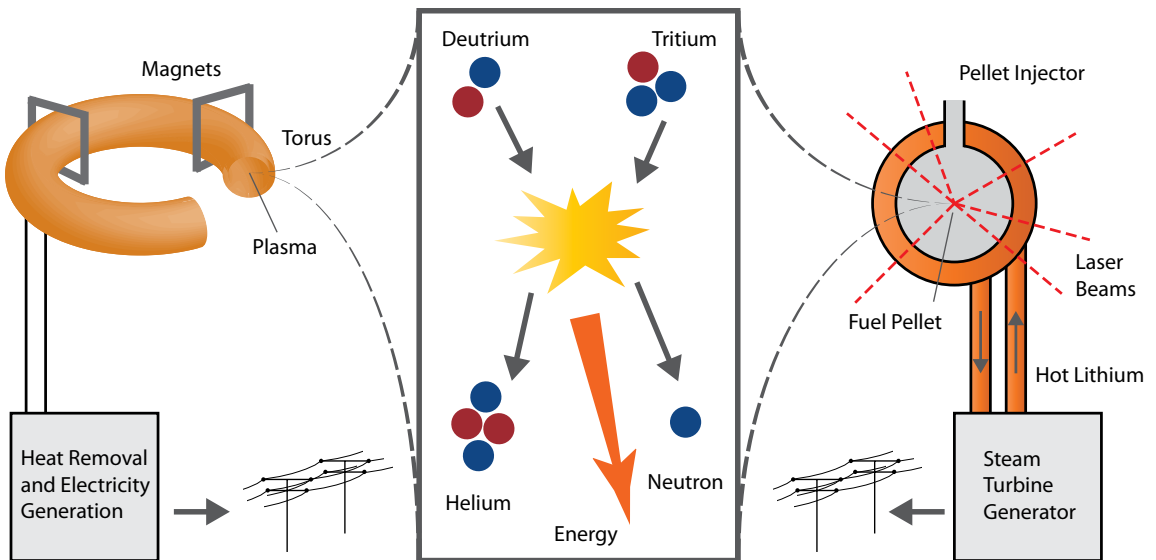
If successfully contained, stimulating fusion reactions in the plasma is surprisingly straightforward – it is generating more energy from the fusing plasma than is required to heat and hold it that's the difficult part. If the burning plasma is sustained over long enough timescales the device can produce an energy surplus.

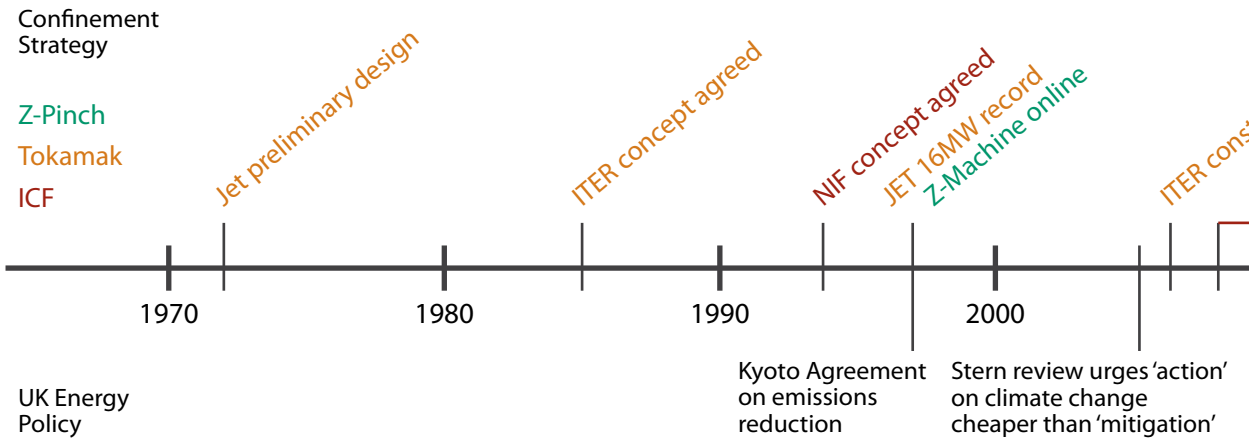
There are two related strategies to ensure that the energy of the fusion products is deposited in the fuel before it escapes. The traditional approach is to heavily insulate

Magnetic Confinement Fusion Device

Nuclear Fusion

Laser Fusion Device





Milestones in recent fusion history shown alongside a 'best guess' timeline to 2050.

the burning plasma. This is achieved by wrapping the fusing plasma in cylindrical sheets of strongly magnetised plasma, a process that hinders the flow of particles (and hence heat) through the fluid. To minimize heat loss as far as possible, the ends of this tube of plasma are joined and held in a doughnut shaped device known as a tokamak. Until the last few years Magneto Confinement Fusion (MCF) was the most mature fusion technology, and in 1997 the Joint European Torus (JET) in Oxfordshire enjoyed fusion runs of a full 10s. They achieved a record-breaking 16MW of fusion power but this fell well short of burn – 25MW of heating was required to maintain the reaction.

The ITER (International Thermonuclear Experimental Reactor), the world's largest and most advanced experimental tokamak, is currently being built at Cadarache in the south of France, with the first plasma expected in 2019. It is hoped that the fusion reactor will produce ten times the amount of energy put in.

NIC @ NIF

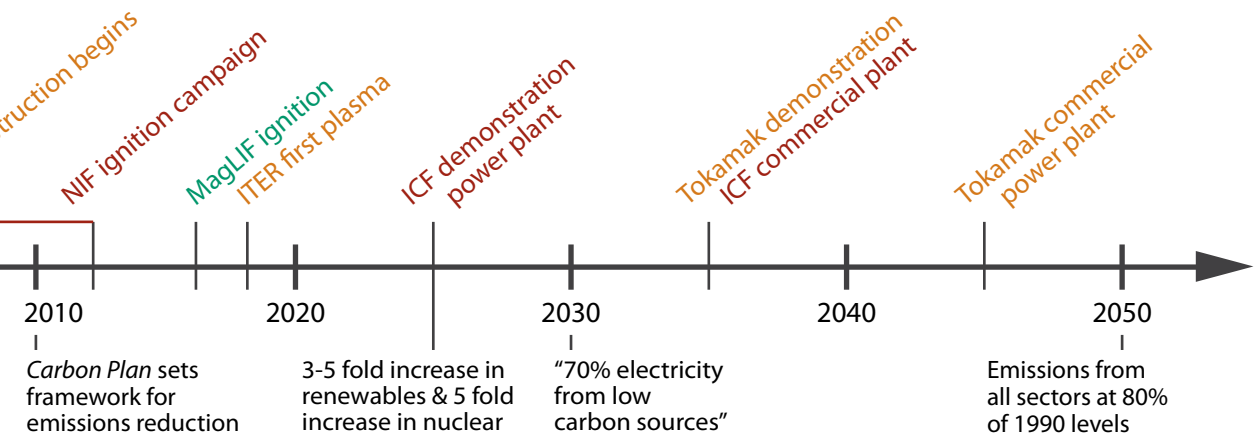
Insulation is not the only method by which sufficient plasma for breakeven can be brought to fusion temperatures. Over the last two years a small satellite town of San Francisco has nurtured mankind's most aggressive

campaign for burn to date. Livermore's National Ignition Facility (NIF) is home to 192 laser beams, the most powerful ever constructed. During each firing sequence (NIF scientists refer to each as 'shots') this field of laser beams bears down on a 2mm capsule of fusion fuel. The strategy here is compression – as the fuel is crushed to ever higher densities its temperature reaches fusion conditions in a central hotspot. Confined under its own inertia, should fusion occur here its energy is deposited in the surrounding plasma, sending a burn wave outwards through the fuel. The result is a miniature H-bomb, contained within a heavy-duty steel vacuum chamber.

Ignition at the NIF is tantalizingly close. The last two years have witnessed meticulous alignment of the 192 beams onto a dummy capsule. Both laser and hohlraum – the small metal cylinder which catches the laser energy and re-directs it uniformly onto the fuel pellet - have been fine-tuned and now deliver a full 1.6MJ to the target – over twice as much energy as in early tests. Latest results indicate symmetrical implosions can be achieved to the required precision to achieve burn.

It is also possible to simultaneously exploit both magnetic and inertial confinement in a device known as a Z-pinch. Here a column of fusion plasma is magnetised around its vertical ('z') axis and then rapidly compressed along the same axis by a pulse of high electric current through the cylindrical liner holding the fuel. Known as MagLIF (Magnetic Liner Inertial Fusion) the concept has yet to be tested in its full form but remains the most theoretically efficient method of raising fuel to fusion conditions.

[1] HM Government (2011) *Carbon Plan: Delivering Our Low Carbon Future*.
 [2] Smith C. L. & Ward D. (2008) Fusion. *Energy Policy*. 36(2008): 4331–4334.
 [3] National Ignition Facility
 [4] Ministry of Science and Technology of the People's Republic of China (2011) [press release] 22 March. Available at: < http://www.most.gov.cn/kjbgz/201103/t20110321_85526.htm >
 [5] UNEP & Bloomberg New Energy Finance (2011) *Global Trends in Renewable Energy Investment 2011*.
 [6] Nuclear Industry Association (2010) *UK Nuclear: Powering the Future*.



In September 2011, NIF announced record neutron yields from a DT capsule. They had achieved densities of more than a kilo per cubic centimeter – less than a factor of three short of the 1.5-3kg/cm³ they predict will sustain a burn wave. With another year of fine tuning ahead, and a further 0.2MJ of laser energy in hand, fusion scientists are on the edge of their seats – will 2012 see the birth of a fusion future? Will we see ignition at NIF?

On paper, there is no doubt burn should, and it will, be possible. Yet some serious technical questions must be answered before energy derived from fusion becomes a reality. Current designs plan to harvest the fusion energy by encasing the reaction chamber interior in a flowing wall of metallic Lithium. This process neatly addresses the twin problems of extracting heat energy from the vessel and generating fresh Tritium fuel – each fusion neutron deposits its energy in the Lithium blanket and transmutes a Lithium atom into one of precious Tritium. But can this process be realized safely? Will it deliver sufficient Tritium and can we extract it? Above all, will it transfer sufficient heat to the steam turbines to generate profitable amounts of electricity/electric power?

Lab to Grid

In the low carbon future painted by The Carbon Plan¹, over 30% of UK electricity will be drawn from renewable sources by 2030, 20% from CCS coal fired plants and a further 20% from an armada of proposed fission reactors. The plan, however, states "It is impossible to predict what the power generation sector will look like in 2030" – clearly there is still room for fusion to be a powerful ally in the quest for 80% lower emissions.

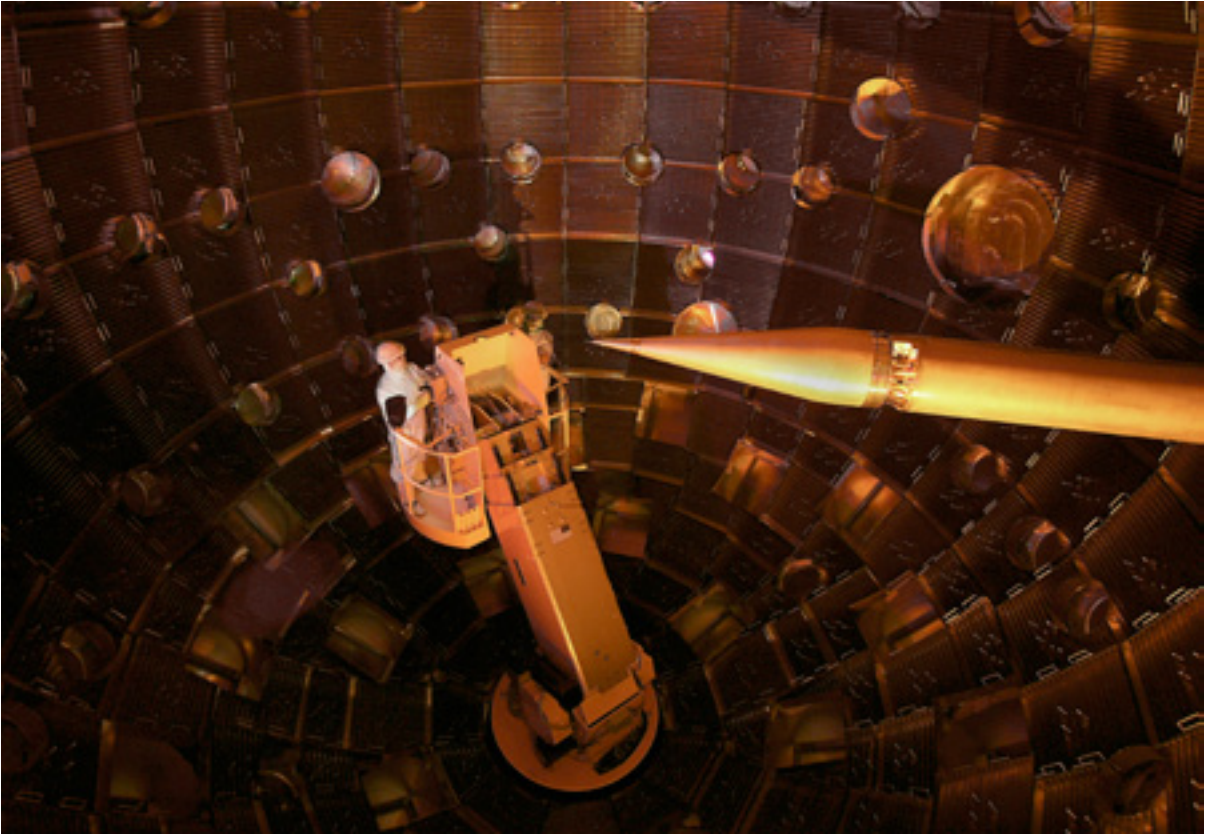
The premise behind fusion-generated power is that, with ignition in hand, we have a process that can take socket electricity and release around ten times more fusion energy. But can we capture it? And can we sell it? These are difficult questions given the uncertainty surrounding future energy prices and capital costs – the only answer for now is: we will certainly try.

The economics favour larger fusion power plants as fusion is capital-intensive with low operating costs. Pricing projections are very difficult at this stage given that demonstration plants are not likely to be fully operational for up to 20 years, but models suggest that fusion could play a major role in the second half of the century². This will depend on the cost of fusion power relative to the cost of alternatives and environmental and market constraints such as carbon pricing.

If NIF succeeds, the reaction of the international community will be swift as it is well prepared. NIF scientists have already drafted plans for an ICF power plant – taking the ignition process and getting its energy onto the grid. The LIFE project plans for a NIF scale facility to be generating 400MW by the mid 2020s. Similar timelines apply to DEMO, a follow-on commercial demonstration plant proposed by ITER. If successful, GW scale stations could be on the market as early as the mid 2030s.

Funding Fusion

Fusion is an expensive experimental-facility dependent science. With a single NIF fuel pellet costing £25,000, and the entire project at £2.5bn³, it is no surprise that global economic conditions affect these world-leading



Inside the target chamber at NIF: Will the world's most powerful lasers achieve ignition within the next 12 months?

facilities. Indeed, such is the level of investment and international cooperation required per reactor that it was Thatcher, Reagan and Gorbachev who commissioned the ITER tokamak in 1985, construction of which ultimately began in 2007. Today, it finds itself in an economic environment unable to shell out for its spiralling construction costs.

At a 34% stake, it is the EU who bears the financial brunt of this crunch – last year's £1.2bn shortfall in construction payments, ultimately resolved by a heroic re-jig of some future EU budgets, is the tip of the iceberg when it comes to financing the facilities required to steer towards DEMO.

The US hedges their bets with a 13% stake in ITER – ensuring their plasma scientists will be at the cutting edge in the tokamak community should the NIF fail. With a 10% share in ITER, China is involved in cutting-edge fusion for the first time, and they claim⁴ to be training 2,000 new plasma specialists to ensure a return on their investment.

A Future for Fusion?

All eyes are on Livermore. Will laser-driven fusion finally unlock the power of the hydrogen atom? If NIF achieves ignition this year it will be a long overdue morale boost for the scientists and politicians who have supported these long-running fusion initiatives. It will also ensure future funding for LIFE, DEMO and other demonstration fusion power-plant projects, and support for further research on tokamak and Z-pinch approaches: it is too early to rule out any alternative, potentially more efficient, fusion strategies.

Investment in renewables is at an all time high, with global spending at over £130bn⁵ in 2011. The British nuclear industry alone anticipates a £300bn⁶ bill for the next generation of fission plants. The global environment is at stake and the future of the energy sector is to play for – whatever happens at NIF next year there is surely room to drive their findings ahead with renewed intensity to realise the incredible potential of fusion.

Philip de Grouchy & Arthur Turrell are PhD students in the Plasma Physics group at Imperial College London.

Quantum Vision 2050

Dr. Herbert Wiklicky, Imperial College London

In 1982 Richard Feynman proposed to utilise ‘quantum computers’, employing quantum mechanical phenomena such as superposition and entanglement, in order to perform resource intensive computational tasks, followed in early the 1990s by a breakthrough from Peter Shor and Lov Grover who described quantum algorithms for factorising and search which are substantially faster than their classical counterparts.

The conceptual and practical problems with quantum computation are mainly related to the process of extracting information via measurements – the uncertainty in the measurement of the system has important implications as one has to distinguish between what is computed by the device and the computational result extracted. Looking to the future, it is to be expected that at some stage quantum effects will start to play a role on integrated circuits such as the ones we use on a normal PC. At this stage we need to decide whether or not we consider this to be a bug or a positive feature: do we reject a device that does not behave according to classical Boolean logic as faulty or do we adapt to accommodate this new quantum logic?

The year 2012 will be celebrated by many in the computing community as Turing Year, in commemoration of the 100th birthday of Alan Turing. Turing is commonly regarded as the mathematician who laid the theoretical foundations of computer science by introducing what now is called the Turing Machine. This theoretical model provides the basic ideas of what constitutes a ‘computation’ as a mechanised, step-by-step process. Some people have criticised various aspects of this model as providing only hypothetical ‘paper machines’ rather than real physical devices.

If one follows this argument then one has to accept the fact that computing is fundamentally a physical process and thus limited by physical constraints. One such limitation is the necessary ‘heating up’ of computational devices – a real and major problem for large server farms – which is essentially due to the irreversibility of information erasure. In 1871 James Clerk Maxwell introduced a thought experiment that could demonstrate that the Second Law of Thermodynamics, which asserts that entropy cannot decrease, has only statistical certainty¹. While investigating the implications of ‘Maxwell’s Demon’, scientists such as Leo Szilard, Leon Brillouin, Rolf Landauer and Charles Bennett established the thermodynamic limitations of computation. In particular, Landauer’s Principle states that an increase in entropy resulting from the erasure of information is compensated by a release of heat energy.

Other physical constraints on what can be computed in the real world stem from various fundamental physical theories. For example, special relativity postulates that the maximal communication speed is equal to the speed of light. Similarly, general relativity imposes a particular structure on a computational system, e.g. related to the ‘loss of information’ in black holes, but this seems to be of rather minor importance at the moment, perhaps due to the fact that we do not use solar systems or galaxies to perform computational tasks. What is, however, undeniably an open issue in computing is the effect that quantum physics has on computational machines.

[1] Leff, H. S. & Rex, A. F. (2002) *Maxwell’s Demon 2: Entropy, Classical and Quantum Information, Computing*. CRC Press.

In 1982 Richard Feynman proposed quantum computing in order to perform resource intensive computational tasks, not least in order to simulate concepts in quantum physics. In the following years scientists like David Deutsch developed these ideas further and in the early 1990s a breakthrough came when Peter Shor and Lov Grover described fast quantum algorithms for factorising and search. At about the same time, Charles Bennett and Gilles Brassard and later Artur Ekert developed quantum cryptographic protocols which utilise the properties of quantum systems in order to protect information exchange from eavesdropping.

If we look at the practical implications and potential of quantum computers and quantum computation now, and in the future, we have to understand the particular features of quantum systems as compared to classical systems. Without doubt, one can say that quantum physics is a mathematically well-understood theory – however, it is often said that nobody really understands quantum physics intuitively, even great minds like Feynman. Indeed, there are legions of popular science books discussing the question of ‘what constitutes quantum reality?’ Intriguing Gedanken experiments like Schroedinger’s cat or the Einstein-Podolski-Rosen paradox tend to confuse more than they explain when discussed in a mathematics-free form.

Heisenberg’s Uncertainty

Perhaps the most important conceptual issue in quantum theory is the distinction between the state of a system and observations of that system. In classical physics

we can observe whatever we like about a system and, if we are careful, the system will not care about whether we observe it or not. Thus, we are used to identifying what we see with what there is. In quantum physics the situation is completely different: we have to distinguish between the state of a system and its observations. Though we still might know everything about the state of a system – for example, because we know how it was created – still we cannot measure all of its properties.

Quantum computers ... encode information or memory as quantum bits, or qubits, which can exist in combination or superposition, and thus allow us to compute with many different inputs at the same time

The relationship between state and observables is also complicated by the fact that, when we measure a quantum system, the measurement results are in general not uniquely determined by the state; instead both are related to each other

statistically. There are well-defined probabilities that a particular state will give rise to certain measurements but this is not a one-to-one relation. Furthermore – no matter how careful we are – in general measuring a system changes the state of the system.

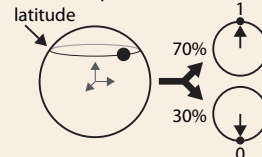
In quantum computing this has important implications for quantum memory. Today’s computers, like a Turing machine, work by manipulating bits that exist in one of two states: a 0 or a 1. Quantum computers aren’t limited to two states; they encode information or memory as quantum bits, or qubits, which can exist in combination or superposition, and thus allow us to compute with many different inputs at the same time. If we build quantum memory from qubits, then their capacity to store information increases not linearly but exponentially, thus increasing computational power

Qubits explained

A bit can have one of two states: 0 or 1. A qubit, the quantum version of a bit, has many more possible states, that can be represented by an arrow pointing to a location on the surface of a sphere. The north pole is equivalent to 1, the south pole to 0. The other locations are quantum superpositions of 0 and 1.



A qubit might seem to contain an infinite amount of information because its coordinates can encode an infinite sequence of digits. But the information in a qubit must be extracted via measurement and quantum mechanics requires that the result is always an ordinary bit, 0 or 1. The probability of each outcome depends on the qubit’s ‘latitude’.



greatly. The reason for this is that qubits are, or can be, entangled, i.e. they are not kept as separate entities – like classical bits – but instead they can only be understood as being part of a greater unit. This gives rise to an increase in information capacity as we record information not as the individual properties of qubits but as properties of the interaction of a whole group of qubits.

The conceptual and practical problems associated with quantum computation are mainly related to the process of extracting information via measurements, i.e. their interaction with classical systems. For example, the uncertainty in the measurement of the system has important implications as one has to distinguish between what is computed by the device from the computational result we extract: the contents of what we see on the output display is fundamentally different from the contents of the quantum memory. Furthermore, if we produce/request an output we change the contents of the quantum memory irreversibly, and the results we get are only probabilistically related to what the device had computed.

Hence, measurements both reduce what we can actually compute and are irreversible. Both of these conceptual problems can, to a certain degree, be overcome and exploited. We can, for example, compute internally a large number of potential results but ultimately check only a single or a subset of relations between them.

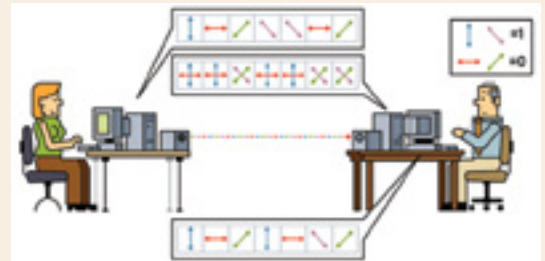
The observational sensitivity of quantum systems – often referred to as the decoherence problem – however makes them very unstable or, perhaps more precisely, delicate physical systems. This instability can be understood in one way as non-intentional observation of a quantum computer/memory by completely unrelated objects maybe in another, far away galaxy. Alternatively, one can also argue that the whole universe is described by one big quantum state in which everything is entangled with everything else. Isolating qubits from external influences or compensating for such interactions, e.g. via error correction, is perhaps the biggest engineering problem currently in quantum computation.

State of the Art

After the announcement of Shor’s factorisation algorithm and Grover’s quantum search in the 1990s much hope was placed on ‘quantum speedup’ that would

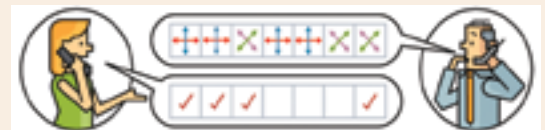
Quantum Key Distribution

Quantum key distribution uses quantum mechanics to guarantee secure communication. It enables two parties to produce a shared random secret key known only to them, which can then be used to encrypt and decrypt messages.

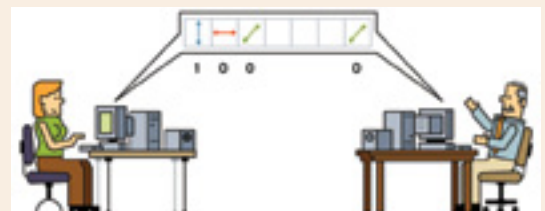


Alice sends a random series of bits, each bit encoded as one of four possible polarisations of a photon. (Only a few photons are shown; in practice thousands would be sent.)

To detect the bits, Bob randomly selects a series of photon detectors [second row]. They are of two types: one accurately detects any photon with a horizontal or vertical polarisations and the other any photon polarised at +45 or -45 degrees. When Bob’s detectors match Alice’s photon, her photons are detected correctly. But the rules of quantum mechanics decree that a photon that does not match the detector’s orientation may still be detected as one that does. Thus, Bob correctly detects only some of the photons [bottom row]. To correct for this ...



Bob tells Alice the series of detectors he used [top row]. Alice tells Bob which of his choices correctly detected her photons [bottom row].



Bob and Alice keep only the bits that were detected correctly and use them as their cryptographic key.

[2] Singh, F. (1999) *The Code Book: The Evolution of Secrecy from Mary, Queen of Scots, to Quantum Cryptography* (1st ed.). Doubleday, New York, NY, USA.

allow improvements in algorithmic design. Not least it seemed that quantum computation could provide cryptographic attacks, for example against common public key systems such as RSA encryption. However, despite some new results including general so-called hidden-group problems, there have been disappointingly few new developments. Although quantum computers cannot compute more intelligently than classical machines – undecidable problems remain undecidable also in the quantum world – it had been hoped that perhaps an exponential speedup could be achieved for many problems that are classically computationally hard. Unfortunately this remains an open issue.

Perhaps the most active development in quantum computation is with regard to various computational models or schemes. These proposals try to provide frameworks for describing and analysing quantum algorithms while exploiting certain quantum features. The starting point was quantum circuits that describe internal computational steps via basic steps employing what are termed quantum gates. Other proposals include one-way or measurement-based quantum computation that exploits entanglement in combination with appropriate basic measurements in order to perform certain quantum transformations, or topological quantum computation that aims to construct a framework that is largely immune to external influences. Other developments in this area investigate various description formalisms and programming languages that enable a precise description of quantum computational processes.

Perhaps the most practically successful development relates to quantum cryptographic protocols. These exploit measurement sensitivity in such a way that interferences with a transmitted message are detected so that countermeasures can be undertaken. Already today some products based on these ideas, such as quantum key distribution, are commercially available.

Despite a number of successful experimental setups (and non-confirmed claims) it seems that nobody has yet successfully constructed a quantum computer of reasonable size. This seems to be mainly related to the decoherence problem as discussed above. Looking at the history of classical computing, it could be suggested that without semi-conductors it would have been

impossible to reach the current level of development, despite the theoretical work of Turing and colleagues on the development of vacuum tube based computers. However, it is hard to forecast any parallel development of ‘quantum transistors’.

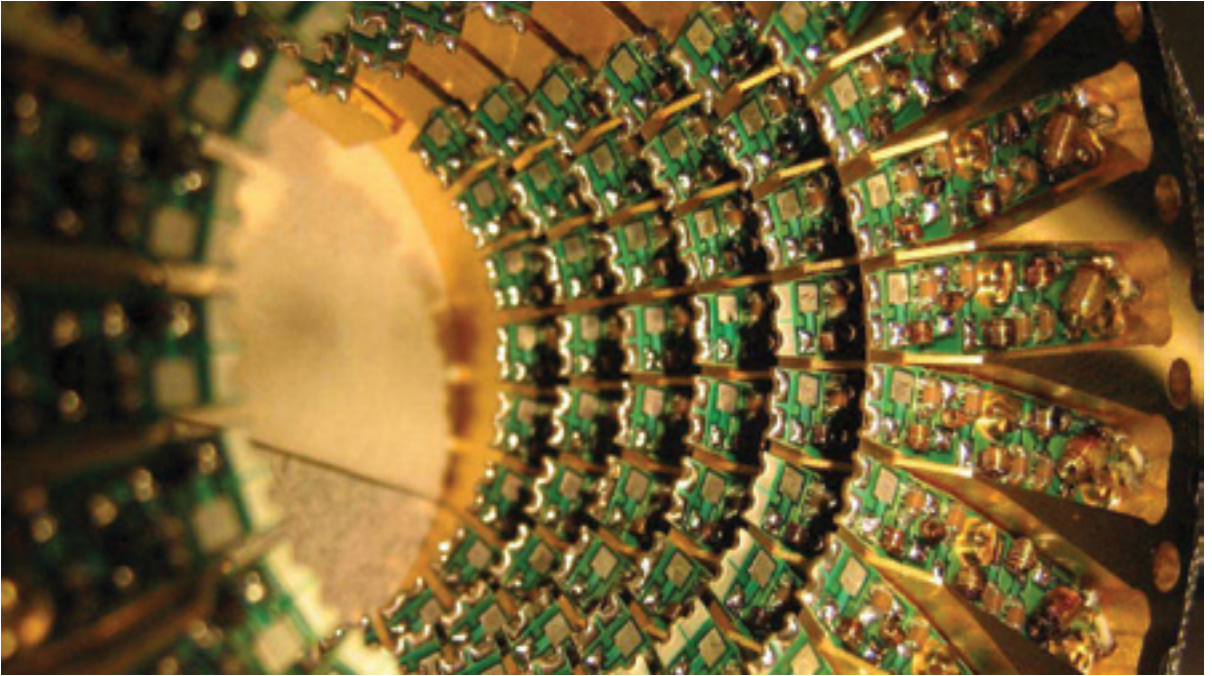
Quantum Computing of the Future

Clearly, the future in a historical situation such as ours, with accelerated technological development, is hard to foresee. Indeed, if previous forecasts had turned out to be correct London would be buried under a huge pile of horse manure or suffocating from fumes and pollution. Maybe we can always just see a step ahead rather than look towards 2050. What will happen depends not only on ingenuity, luck and unexpected discoveries, but also on what is possible and what is needed given the laws of nature, economics – and politics.

While physicists start with a quantum dynamical system as it exists in nature and try to describe it and to forecast its behaviour, we have a different, or opposing, situation when it comes to computing. Here we need to describe a desired behaviour in order to achieve a certain result. Given that our existing, classical specification and programming languages fail in principle when it comes to describing quantum computational processes, it will be necessary to develop such calculi and language. The task is to perform this in relation to the right quantum computational model, ideally also reflecting the actual hardware situation. This is essential also when it comes to analysing and modifying quantum algorithms/programmes.

Although Moore’s Law describing the rapid miniaturisation of classical computing devices remains accurate, it is slowing down and it is to be expected that at some stage quantum effects will start to play a role on integrated circuits such as we use on a normal PC. It remains to be seen whether we will view this uncertainty as a bug or a positive feature in the future: will we adapt to accommodate this new quantum logic?

It seems that adaptation of PCs is a more plausible way of introducing quantum computation, rather than via purpose-built quantum computers. The latter seem to be currently too difficult to build. However, maybe unforeseen discoveries like super-conduction



In 2007, US company D-WAVE claimed to have built the world's first quantum computer yet many in the scientific community remain sceptical

materials at high temperatures might change the situation drastically.

The 'over-sensitivity' of quantum systems that makes it difficult to isolate individual qubits, yet allows us to design successful quantum cryptographic protocols, could play an important role in a highly controlled society. Quantum observations are by their nature irreversible and thus any intrusion can be detected. This could provide a very effective tool to protect privacy, trust and enable surveillance (like the hair in Winston's journal in Orwell's 1984). Schemes like the ones in quantum communication or Stephen Wiesner's quantum money² could provide the first steps in this direction. Possible applications which exploit the fact that quantum systems necessarily possess a kind of intrusion detection mechanism could include cloud computing, enabling users to detect if service providers interfere with data in a non-agreed way – even in the case where they just copy or clone it.

However, there might be legal challenges to this approach related to, for example, the Regulation of Investigatory Powers Act 2000 (RIP) in the UK. If quantum data is required to be revealed to the court or police this could cause two kinds of problem: on one hand, as we have seen, it is in principle impossible to measure or extract all properties of quantum memory so some information

always remains unknown. No power in the world can order its disclosure and the owner of this data must therefore fall foul of the RIP requirements, and on the other hand the information is to some extent destroyed solely by the act of disclosure, which raises the question of damages and compensation. Legal requirements like RIP might thus turn out to be a major obstacle in the development of quantum computation, in a similar way perhaps to the ancient requirement that any carriage not drawn by a horse had to be preceded by a man waving a red flag.

It is likely that quantum computing applications to privacy protection could be the most important development in this area by the mid-century. If the only thing that is worth stealing is information, then observational detection is of utmost importance. However, if in 2050 we live in an over-heated, drowning, and starving world, then an old AK47 might be more valued than any smart device equipped with quantum intrusion detection.

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Turning Local: From Madrid to Moscow, the Internet Is Going Native

David Dean & Paul Zwillenberg, *The Boston Consulting Group*

The Internet is heralded as a global ‘network of networks’, but it is increasingly acquiring a local character that springs from national heritage as well as economic, political, and social influences. It has helped to digitally knit the world closer together but has also spawned many local offspring.

As the Internet becomes increasingly enmeshed in commerce and society, its evolution is being influenced by the physical world – for instance, the rise of secure-payment mechanisms through credit cards and strong logistics infrastructure. At the same time, traditional companies that embrace digital technologies such as social networking can enhance their existing strengths. We are witnesses to a real-time blending of the real and online worlds that has nothing to do with online games, virtual reality, or other entertainment. The winners will be the companies and countries that can successfully marry bricks and clicks.

In some countries, such as the U.K., consumers have become avid online shoppers, but this has not happened in the Netherlands, even though the fixed-broadband infrastructure is much stronger there. The reason lies largely in the physical world: the Dutch are light credit-card users. Hong Kong, which also has a strong Internet infrastructure, has relatively weak business-to-consumer activity. Traditional merchants in this densely populated ‘shoppers’ paradise’ have an easier time holding onto nearby customers. But strong business-to-business Internet activity exists. Pioneering trading companies such as Li & Fung Limited, a global supply-chain manager, have leveraged the strong Internet infrastructure to become global giants, relying on the Internet to enable efficient and

cost-effective information flows among trading partners. In Indonesia, mobile Internet usage is skyrocketing as consumers bypass fixed-broadband Internet access and jump to mobile services. The same is true in India, where, for many customers, their first bank account could well be a mobile one.

Although Facebook has had remarkable success in Western Europe, it faces stiff local competition in China, Brazil, and Russia from firms such as Renren, Orkut, and VKontakte, respectively. Likewise, Amazon.com and Google have strong local competitors in countries such as Japan and Russia.

It should not be surprising that the Internet is evolving differently in different places. The way in which technology and media take root has depended on each country’s local characteristics. Cable television, for example, has been much more successful in the small high-density Benelux countries than in Italy, where satellite providers skimmed the best customers while cable companies were still digging ditches. In Eastern Europe, magazine publishing is a growth business because the nations there are still developing the consumer economy upon which magazines depend for advertising revenue. Not so in the U.S.

These observations emerge from several strands of research conducted by The Boston Consulting Group, including an initiative commissioned by Google.

BCG e-Intensity Index

To generate a more nuanced picture of the depth and reach of digital activity across countries, the BCG e-Intensity Index analysis compares different measures of Internet activity for 50 countries. These include all Organisation for Economic Co-operation and Development

(OECD) members, the BRIC nations, and other noteworthy economies such as Hong Kong, Saudi Arabia, Singapore, and South Africa. It measures three key characteristics:

- **Enablement.** How well built is the infrastructure and how available is access? (This has a weighting of 50%)
- **Expenditure.** How much money is spent on online retail and online advertising? (25%)
- **Engagement.** How actively are businesses, governments, and consumers embracing the Internet? (25%)

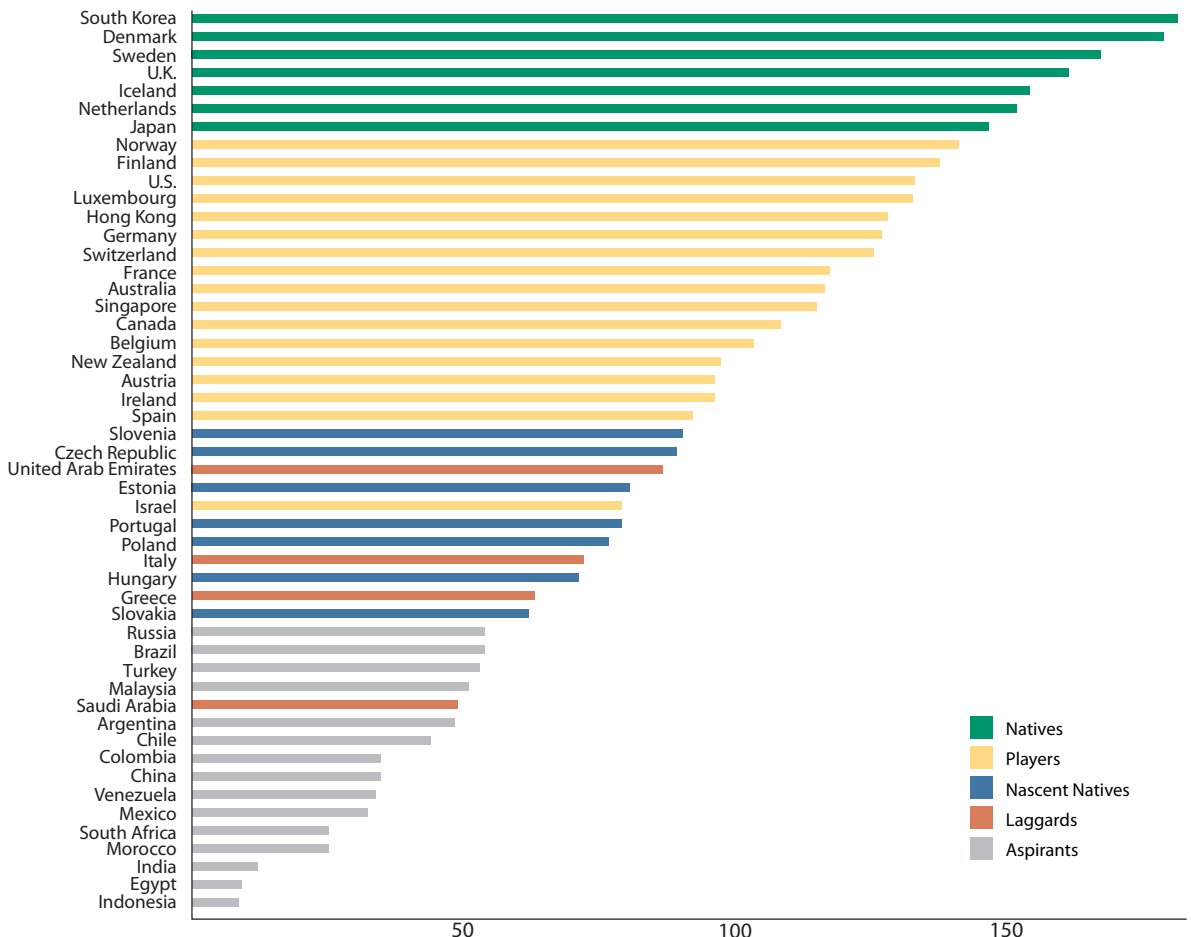
BCG e-Intensity Index captures a nation's supply of Internet infrastructure (enablement) and the demand for Internet services (expenditure and engagement), providing a clearer understanding of a nation's strengths and weaknesses than other global rankings.

From Natives to Aspirants

We analysed the strengths and weaknesses of the 50 nations and found that, based on the level of their digital activity, the nations break down into five clusters.

Natives. The seven nations that top the index are from Northern Europe and the advanced economies of Asia: Denmark, Iceland, Japan, the Netherlands, South Korea, Sweden, and the U.K. Strong infrastructure and broadband penetration help power these nations to the top of the index, but many of them have more than just better pipes. South Korea, the top-ranked nation, placed in the top four across the board: in enablement, expenditure, and engagement. Denmark, the nation with the second-highest overall ranking, scored fifth in enablement, first in expenditure, and eighth in engagement.

The BCG e-Intensity Index highlights Internet prowess across economies



Sources: ComScore; Economist Intelligence Unit; Euromonitor International; Gartner; International Telecommunication Union (ITU); Magnaglobal; Ovum; Pyramid Research; Speedtest.net; United Nations; World Bank; World Economic Forum; BCG analysis.

Note: The index is scaled so that the geometric mean is 100 for the 34 OECD member countries.

The lesson for executives and stakeholders in developing nations and other countries that want to improve their Internet profile is clear: investments in infrastructure need to be accompanied by other strengths such as a favorable regulatory environment, strong payment systems, and consumer protections for e-commerce transactions.

Players. The next group is the largest, comprising 17 nations, mostly from Western Europe and rounded out by other developed economies such as Australia, Canada, Hong Kong, Singapore, and the U.S. These nations generally have what might be termed ‘good enough’ Internet infrastructure, commerce, and civic activity.

A lack of consistency across the three Es is what keeps these nations from rising to the top. Hong Kong, for example, had the highest enablement score but fell to twelfth overall by ranking in the 20s in both expenditure and engagement. Belgium could move up in the rankings if companies and consumers embraced online shopping. Seventy-five percent of all Internet users go online nearly every day. But they are engaged more in social than in commercial pursuits. In 2010, the annual volume of online retail sales per capita was approximately \$200, one-third that of the U.K.

The U.S. – the birthplace of the Internet – proves that nations need more than great infrastructure to do well

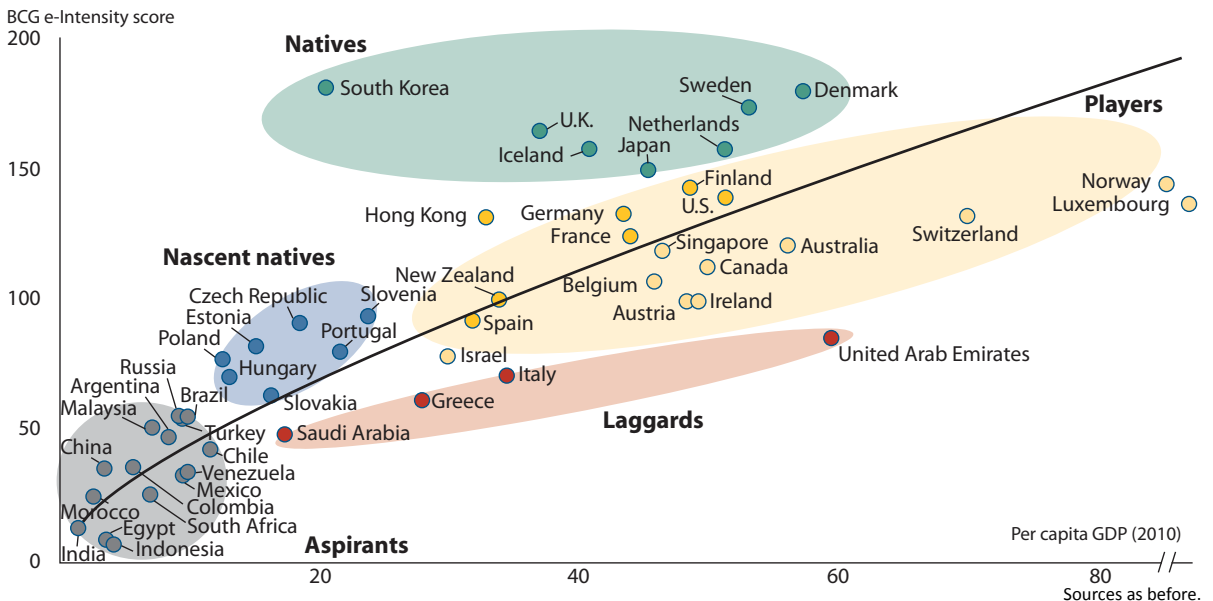
on the index. The U.S. has only the fifteenth-highest enablement score but the top engagement score and the eighth-highest score in expenditure, giving it an overall ranking of ten.

In the future, however, weak infrastructure may start to hobble U.S. performance. Innovative services that require high bandwidth will have a hard time finding a mass-market home in the U.S. outside of high-speed corridors. Less than 40 percent of U.S. Internet connections exceed 5 megabits per second, according to Akamai’s most recent State of the Internet report.

A large share of the U.S. population is simply priced out of the market. “The poverty problem provides a new and sobering lens for any serious analysis of the telecom and media sectors,” says Craig Moffett, an analyst at research firm Sanford Bernstein, in *The Poverty Problem*. “At the low end, customers aren’t just choosing between one provider and another. They’re often choosing between these services and a third meal.”

Nascent Natives. The third group consists of a cluster of seven nations from Southern, Central, and Eastern Europe. They generally underperform in at least one dimension. But there are also examples of leading-edge innovation within these nations, and they could advance quickly if they make the right moves.

The BCG e-Intensity index correlates with per capita GDP



The Czech Republic, in particular, manages to overcome a low enablement score by doing well on the expenditure index. More significantly, that nation is using the online environment to replace immature or undeveloped retail channels. Planet Retail, an analyst firm, estimates that the German and U.K. markets have 35 to 75 percent more retail space per capita and 20 to 30 percent lower relative prices in some categories.

Rather than build out retail space and the accompanying logistics systems, Czech companies are moving online. While the share of online sales varies among product categories, 17 percent of domestic appliances and 14 percent of sports equipment were bought online in 2009.

The challenge for stakeholders and companies is to understand the constraints on Internet activity and remove them. Czech consumers, for example, pay cash on delivery for nearly one-half of online sales. Their unwillingness to accept online payment will eventually constrain growth.

Laggards. Four countries – Greece, Italy, Saudi Arabia, and the United Arab Emirates – should have stronger Internet profiles than they do. They all rank lower on expenditure and engagement than they do on enablement and perform worse on the BCG e-Intensity Index than predicted by their per capita GDP. These nations have the ability and potential to exploit the Internet more fully and could move quickly up in the rankings with focused effort.

The contrast between the Czech Republic and Italy – a country with higher per capita GDP and a longer history of market economics and modern retailing – is stark. Although Italy has a higher enablement score, its overall score is lower. Italian companies and consumers have not yet embraced the Internet to the same extent as their Czech peers. Traditional retailers, for example, have been reluctant to sell online: some 70 percent of online apparel sales are conducted by companies without physical stores.

On the Internet, time often moves at warp speed, and Italy may be overcoming its slow start. Online retail sales in Italy grew by 18 percent last year, according to Euro-monitor International, and online advertising also grew by 18 percent – more than twice the rate in France (8 percent), according to Magnaglobal.

Aspirants. The final group of 15 nations consists of developing economies that trail far behind on several key dimensions. Most of these countries are physically large. On average, the quality and reach of their infrastructure are inadequate, and broadband penetration, online spending, and usage rates are low. But averages belie the fact that many of these nations are truly on the move. Indeed, in some of their metropolitan areas, the Internet experience is virtually indistinguishable from that in London, New York, or Tokyo.

By 2015, the BRICI nations, for example, will have more than 1.2 billion Internet users, more than three times the total in Japan and the U.S. combined. Internet penetration is surging in most of the BRICI countries, with projected annual growth rates ranging from 9 to 20 percent from 2009 through 2015. In China, the average Internet user spent 2.67 hours per day online in 2009, more than the average U.S. user (2.27 hours) and close to the mark of the average user in well-connected Japan (2.87 hours). The number of Internet users in China is projected to grow from 384 million in 2009 to 650 million in 2015.

Furthermore, the level of experimentation and innovation is especially high in these countries. In India, Internet-enabled mobile services are meeting people's agricultural, health, and educational needs. Nearly half of China's digital consumers use their mobile phones for multimedia messaging, photos, and streaming or downloading music. Nearly 40 percent of China's users play games on their mobile phones, and around one-quarter use mobile video, Internet, and news services. Brazil is a hub of online commercial activity, ranking in the top half for business engagement.

In China and Russia, in particular, developments largely resemble the early days of the Internet in the U.S., with vast experimentation, innovation, and imitation. By contrast, Internet activity in many parts of Western Europe has been more a matter of paving over wagon trails – digitizing traditional businesses rather than creating new ones.

Eight of China's ten most popular sites are local. Local companies have succeeded by tailoring their offerings to Chinese preferences. They have deep understanding of the consumer population, localized product offerings, and the ability to work flexibly with Chinese regulators. The top ten sites include search engine, news portal, Web video, business-to-business e-commerce, and instant-messaging sites.

Companies such as Tencent and Alibaba.com have come to dominate the market. Now among the largest digital companies in the world, they have global ambitions. Alibaba.com has 65 million registered users in more than 240 countries and regions, and Tencent – a provider of the instant-messaging platform QQ, online games, and social networking – recently invested in Digital Sky Technologies, a Russian company with significant stakes in Facebook and other global online platforms.

In Russia, also, local companies are leading the way. Yandex is the largest search-engine company and Ozon.ru, the largest online store. Ozon.ru has more than 4.8 million users and is adding 90,000 new users each month. The company generated around \$140 million in revenues in 2010. Customers can choose from 18 methods of payment and 14 methods of delivery.

The Economic Impact of the Internet

The size and nature of the Internet economy provides another lens through which it is possible to explore capabilities and online activities.

BCG analyzed and determined the size of the Internet economy in 12 European countries, Egypt, and Hong Kong. In these countries, the Internet economy ranges from 7.2 percent of GDP in the U.K. to 1.2 percent in Turkey. The size of the Internet economy in each of these countries roughly tracks the country's performance on the BCG e-Intensity Index. In the future, the Internet will also be a major contributor to performance, providing a large share of growth in nations struggling to find economic traction.

The Czech Republic and Hong Kong, both net exporters of Internet-related equipment, have larger Internet economies – measured as a percentage of GDP – than the BCG e-Intensity Index analysis would suggest.

In most markets, consumption makes up the largest share of the Internet economy. In around two-thirds of markets such as Denmark, the Netherlands and Sweden, corporate investment was responsible for 60 to 70 percent of investments, while in less developed countries, this percentage was larger – up to around 90 percent in Russia. Telecom operators in countries with less developed infrastructure, especially Egypt and Turkey, are investing heavily in Internet-related technology – largely 3G and 4G mobile networks that facilitate access to Internet services. These investments could pay dividends down the road by providing infrastructure that will enable

e-commerce and other Internet activities to flourish. To get an idea of the future size and contribution of the Internet economy, we made several projections about its size in 2015. The most important projections were broadband adoption and consumers' enthusiasm for online shopping, both of which drive consumption. Looking forward, we tried to be conservative. Still, several underlying trends – and the response of governments, businesses, and consumers – will be strong and unpredictable influences on growth and value.

The three nations with the smallest Internet economies, in relative terms, Egypt, Russia, and Turkey, have the fastest projected growth rates. Online retail sales account for most of this growth. Although these nations are starting from a smaller base – thus amplifying future gains – their progress is nonetheless encouraging.

With many nations still struggling with the aftershocks of the Great Recession, the Internet can meaningfully contribute to GDP growth. The higher the nation's current score, the larger the likely contribution will be.

In the top-ranking nations on the BCG e-Intensity Index – for example, Denmark, the Netherlands, and the U.K. – the Internet is likely to contribute as much as 15 to 20 percent to GDP growth from 2009 through 2015. In countries in the next tier – for example, Germany and Hong Kong – it will contribute around 10 percent to GDP growth. Among Aspirants such as Russia and Turkey, the Internet is expected to contribute less than 5 percent to overall GDP growth.

Shaping the Future

From Boston to Beijing, from Madrid to Moscow, the Internet is reshaping economies and lives. The Internet is still very young, and in order for it to reach its full potential, several factors will need to come into play.

Advanced Internet services, such as high-quality video and mobile data services, need to run on a rock-solid infrastructure. The popularity of the iPhone and other smartphones, for example, has already taxed the capacity of mobile carriers in many markets. The ability of carriers to create additional capacity – and to set adequate prices – is critical to long-term growth in the Internet economy. Carriers will also need to make tough choices about the share of investments they devote to fixed rather than mobile technologies. Although businesses will depend on fixed infrastructure, the consumer experience will increasingly be a mobile one.

In every country, there is a significant minority of adults who do not use the Internet, forfeiting its benefits. In the U.K., 1 in 5 adults—about 9 million—has never been online.

Universal access and adoption of the Internet are laudable goals and would provide a tremendous boon to national economies as well as new Internet users, who would benefit from better information, lower prices, and a greater range of entertainment choices. These goals, however, have proved difficult to achieve in developed markets, although some countries such as Finland are adopting supportive legislation. In developing markets, stakeholders will need to make tough decisions on the basis of the tradeoffs associated with access, speed, and investment.

If the government is engaged, consumers and businesses are somewhat more likely to follow. Denmark has created a public portal for individuals and businesses to interact with public authorities, and the Netherlands has developed the DigiD authentication system in order, among other things, to improve the efficiency of tax collection and benefits disbursement. The Hong Kong Hospital Authority has taken the lead in encouraging hospitals and clinics to use the Internet for sharing patients' electronic medical records.

The vitality of e-commerce depends on users' confidence in systems that protect privacy and consumer data and that prevent fraud. A failure in any of these systems could fundamentally alter consumers' willingness to make online purchases.

To fully exploit the Internet's potential, a multidisciplinary approach to regulation is necessary. Whether nations vest authority in a single body or several, they need to ensure that regulation is coordinated to encompass telecom, banking, commerce, and consumer affairs. This, though easier said than done, is nonetheless necessary. India, for example, has recently instituted a biometrics-based national identification system that could dramatically expand the ability of banks and merchants to offer Internet-enabled mobile banking and commerce and that could also improve government's ability to deliver social services.

Openness has been a cardinal strength of the Internet, driving innovation and inclusiveness. Some people wonder whether this openness is under threat. The open-versus-closed debate can be polarizing and frequently unproductive. Few truly open systems generate significant economic value. Put differently, the closed nature of a system is what allows its owner to generate profits. Navigating these issues is tricky. Although the Internet's founding fathers may fret over its evolution, regulators would be wise to be guided by restraint in trying to control these complex and fast-moving developments. Government should intervene only when market forces are not working to correct imbalances.

The Internet has created vast wealth for some and changed the destinies of many companies and industries. In many emerging economies, it is contributing to economic growth and, as the recent Arab Spring uprisings so vividly demonstrate, enabling societal change. A century ago, electricity jolted economies and societies in a similar way, and it will not be too long before the Internet is as pervasive as electricity.

The rise of electricity created some industries, destroyed others, and transformed most of the rest. The Internet is doing the same, so it is not unnatural for stakeholders to be inclined to intervene and attempt to chart the Internet's future. But they need

to tread with caution. Picking winners is fraught with difficulty, and incubating the next Google, Facebook, or Twitter is unlikely to be successful. Instead, stakeholders—especially those in the developed economies—should ensure that market conditions encourage both existing companies to fully exploit the Internet and startups to create Internet businesses that play to a nation's core strengths. This approach will provide a platform for growth and societal benefit greater than wishing upon an Internet star.

Advanced Internet services, such as high-quality video and mobile data services, need to run on a rock-solid infrastructure. The popularity of the iPhone and other smartphones, for example, has already taxed the capacity of mobile carriers in many markets

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Elearning for Tackling the Health Worker Shortage

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Space travel and global health have more in common than is evident at first glance. In the last 15 years, the European Space Agency has been exploring how information and communication technologies can improve health worldwide. One use of these new communication technologies – eLearning – could help tackle the estimated 4.3 million global shortage in health workers, whose ranks need to be sufficiently increased if Millennium Development Goals (MDG) targets are to be achieved¹. ELearning is especially promising in sub-Saharan Africa where remote areas need a better supply of services. But how feasible has online eLearning for health worker training been so far? And what obstacles will it face in the future?

The World Health Organization (WHO) estimates that 2.4 million nurses, midwives and physicians and 1.9 million health aid workers, pharmacists, technicians and auxiliary personnel are needed to meet MDG targets². Africa, which is having the most difficulty reaching the

MDGs, has been hit hardest by the health worker shortage. WHO's World Health Report 2006 states that the African continent is facing 24% of the global burden of disease but only possesses 3% of the global health care workforce.

Elearning, or computer-assisted distance learning, can help broaden the skills of existing professionals, reach those who live in geographically isolated areas and reduce costs of learning-related travel

Child deaths and maternal mortality have hit low-income countries the worst. The risk of a death for a woman during childbirth is 1 in 31 women in low-income countries, compared to only 1 in 4,300 in high-income countries³. Moreover, 7.6 million children under the age of 5 die each year, with children in low-income countries being 18 times more likely to die than those in high-income countries.

Most of these deaths are preventable. Ready-to-use high-nutrition foods, optimal breastfeeding, and safe complementary feeding can reduce malnutrition and have the potential to save millions of lives. The provision

[1] WHO (2008) Numbers of health workers insufficient, states report. [online] Available at: <<http://www.who.int/workforcealliance/news/education-taskforce-report/en/>> [Accessed 26 November 2011]
[2] WHO (2006) *The World Health Report 2006*.
[3] UN (2010) *The Millennium Development Goals Report 2010*.
[4] WHO (2007) Task shifting to tackle health worker shortage. [online] Available at: <http://www.k4health.org/system/files/WHO%20task_shifting_booklet.pdf> [Accessed 28 November 2011]
[5] WHO (2011). Children: reducing mortality. [online] Available at: <<http://www.who.int/mediacentre/factsheets/fs178/en/index.html>> [Accessed 23 November 2011]
[6] Bastable S., Gramet P., Jacobs K. & Sopczyk D. (2011) *Health professional as educator: principles of teaching and learning*. Sudbury: Jones&Bartlett Learning.
[7] Maheu M., Whitten P. & Ace A. (2001) *E-Health, telehealth, and telemedicine: a guide to start-up and success*. New York: Wiley Company.

[8] Kumar, P. (2007) Providing the Providers – Remediating Africa's Shortage of Health Care Workers. *The New England Journal of Medicine*. 356: 2564-67.
[9] WHO. Country case study: Ethiopia's human resources for health programme. [online] Available at: <http://www.who.int/workforcealliance/knowledge/case_studies/Ethiopia.pdf> [Accessed 26 November 2011]
[10] The Open University. HEAT programme: Our Partners. [online] Available at: <<http://www8.open.ac.uk/africa/heat/about-us/our-partners>> [Accessed 25 November 2011]
[11] Long, L. A. (2011) Turning the HEAT up for frontline health workers in Ethiopia. [online] Available at: <http://www.africa-health.com/articles/may_2011/HEAT.pdf> [Accessed 27 November 2011]
[12] Heat Blog. HEAT Resources. [online] Available at: <<http://www8.open.ac.uk/africa/heat/heat-resources>> [Accessed 25 November 2011]
[13] Partners in Population and Development Africa Regional Office. Ethiopian Health Extension Programme.

of skilled care during pregnancy and the presence of a skilled birth attendant significantly increase the chance for newborn survival. However, for the achievement of MDGs 4 and 5 – the reduction of child mortality by two-thirds and the improvement of maternal health – it is estimated that approximately 819 000 additional health workers are needed in the African region; an increase of 139% compared with current levels. The skills of existing health workers must be broadened in order to compensate for this shortage, permitting them to provide a wider range of health services^{4,5}.

In six regions of Ethiopia, a pilot group of 1,000 health workers are being trained online with support from 100 tutors

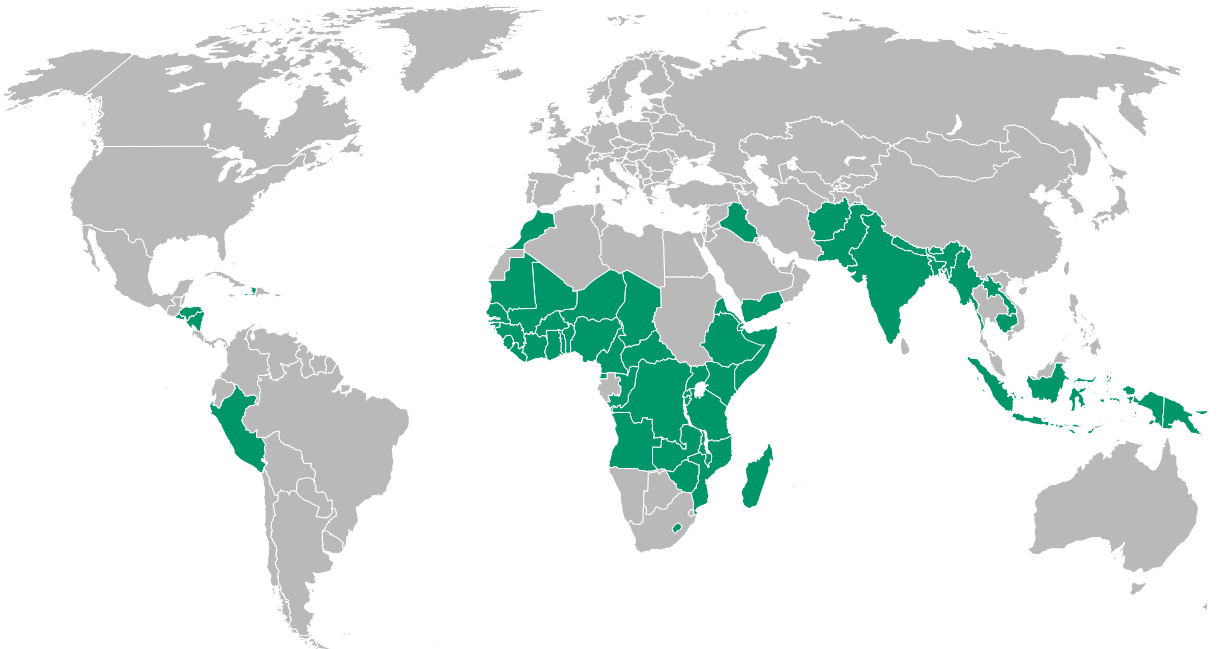
Elearning, or computer-assisted distance learning, can help broaden the skills of existing professionals, reach those who live in geographically isolated areas and reduce costs of learning-related travel^{6,7}. In the face of a health worker shortfall, the advantage of elearning is that health workers from remote locations do not need to leave their post for training. Online training allows them to learn theoretical components at work or at home, so that they can broaden their skills whilst continuing to supply crucial services to their communities⁶.

The Ethiopian Experience

Ethiopia is one of 57 countries identified by the World Development Report 2006 as being unable to achieve a basic standard for health care coverage in the near future^{8,9}. In early 2011, the Ethiopian government launched the elearning programme 'Health and Education Programme' (HEAT) together with the Open University, the African Medical and Research Foundation (AMREF), the WHO and UNICEF (Ethiopia)¹⁰. In six regions of Ethiopia, a pilot group of 1,000 health workers are being trained online with support from 100 tutors, in order to broaden their skills¹¹. The course is composed of 13 modules consisting of 450 hours of training that are freely available on the Internet. They encompass subjects such as the management of childhood and newborn illnesses, labour and ante- and postnatal care, hygiene and family planning¹².

This is not the first training programme the Ethiopian government has initiated for health workers. In 2003, it invested in health worker vocational training for young women with 10th grade education¹⁰. Over 6 years – from 2003 to 2010 – 30,000 women became health workers¹³. Though this programme made an important contribution to broadening health services in remote areas, it required the young women to travel to training centres for their education. The advantage of HEAT is that it can

Countries with a critical shortage of health service providers (doctors, nurses & midwives). Source: World Health Report 2006



reach more people in a shorter period of time. The director of HEAT, Lesley-Anne Long, states “There are some really good training projects happening all over Ethiopia, but they are dealing with 10 students here, and 20 students there. We are talking about reaching thousands and thousands of students.”¹⁴ With appropriate funding, HEAT could broaden the skills of 250,000 health workers across sub-Saharan Africa by 2016¹⁴.

Another advantage of eLearning is that the training is delivered using local infrastructure. Local health science colleges function as regional distance learning centres where tutors from partner NGOs deliver practical skills training and assessment in conjunction with the online training. In this way, the responsibility of the programme and the evaluation of students can remain in each region¹¹. Also, students can meet with tutors when collecting their monthly salary at the regional centre, allowing for better integration of work and training¹⁵.

Moreover, training within the community keeps the teaching tailored to local needs. The content of the courses has been developed with 50 leading African academics and health practitioners. As Long says, “at some point we back out of the picture and what we leave here are people who can write their own curriculum.”¹⁹ Moreover, local experts give students practical advice, an example being guidance on implementing supplementary feeding programmes that are based on the demand of their community¹⁴.

Scaling Up eLearning – A Long Way to Go

There is great potential for the scaling up of eLearning projects. Discussions for the extension of HEAT have taken place with Ghana, Rwanda, Kenya, South Africa,

Nigeria, Southern Sudan, Uganda, Tanzania and Zambia. Moreover, India, Pakistan, Afghanistan and South American countries have shown interest¹⁶.

However, the use of eLearning is facing infrastructural problems that need to be overcome. The availability of broadband in Ethiopia is restricted. Therefore, the theoretical material of HEAT needs to be available both online and offline in a printed format. Remote areas in developing countries will only fully benefit from eLearning when the broadband infrastructure has been extended.

First steps have been taken towards the delivery of better broadband. In October 2011, UNESCO and the International Telecommunication Union (ITU) organized a Broadband Leadership Summit in order to emphasize the importance of access to stable broadband in developing countries¹⁷. Under the theme ‘Broadband for a Global Good’, the Broadband Commission for Digital Development headed by senior policy makers, international organizations and industry leaders made commitments to enhance broadband access in developing countries¹⁷. Moreover, alternative routes are being explored. The initiative uses mobile technology to provide students with access to telephone tutorials. A Java application is currently being tested by AMREF in order to distribute eLearning material on mobile phones¹⁸.

The cost of eLearning is another potential obstacle to a large-scale rollout. Distance learning resources that are contextualised and up-to-date are expensive and tutorial staff need to be paid for the practical support and monitoring of student progress¹¹. The funding of HEAT amounts to around £2.8 million and another £10 million would be needed for the rollout over 9 sub-Saharan countries¹⁹.

[14] The Open University (2010) The OU launching the HEAT programme in Ethiopia – a visit to a local health centre. [online] Available at: <<http://www.youtube.com/watch?v=m3JE0x84DEA>> [Accessed 28 November 2011]

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[16] The Open University (2011) *HEAT Briefing paper*.

[17] UNAIDS (2011) Megabits and MDGs: How broadband can work for greater good. [online] Available at: <<http://www.unaids.org/en/resources/presscentre/featurestories/2011/october/20111025mbitsmdg/>> [Accessed 27 November 2011]

[18] Iheed Institute (2011) mHealth Education: Harnessing the Mobile Revolution to Bridge the Health Education & Training Gap in Developing Countries. [online] Available at: <http://www.mhealthed.org/iheed-report_updates.pdf> [Accessed 25 November 2011]

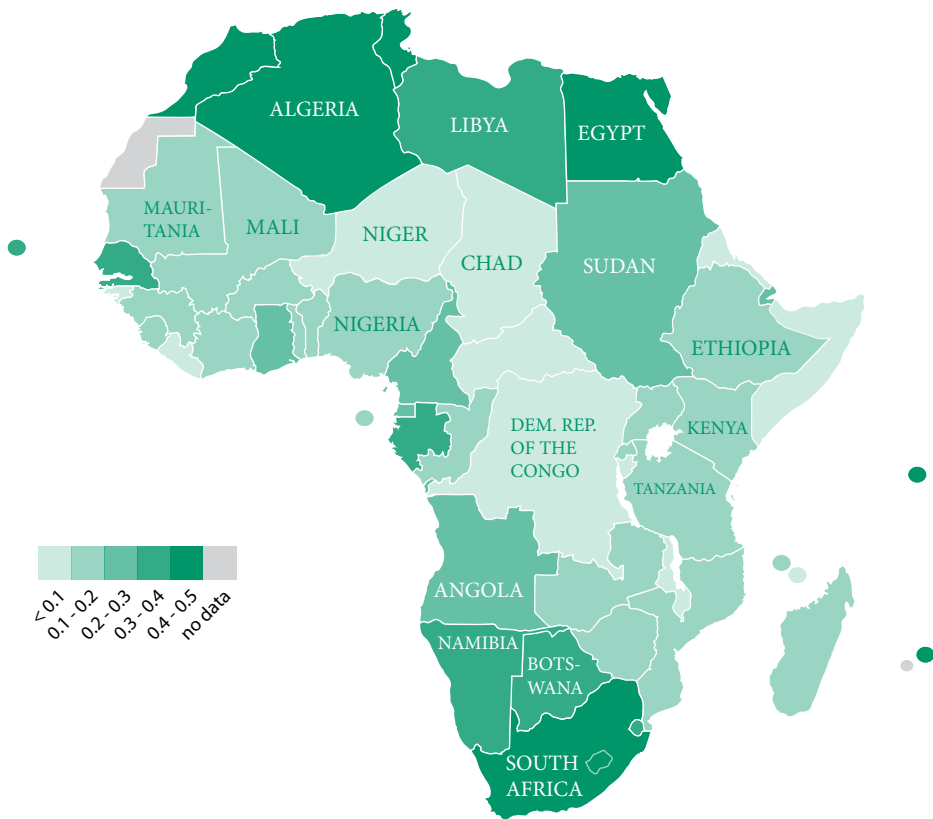
[19] The Open University. HEAT programme: Support our work. [online] Available at: <<http://www8.open.ac.uk/africa/heat/about-us/support-our-work>> [Accessed 25 November 2011]

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[23] Kuehn B. M. (2007) Global Shortage of Health Workers, Brain Drain Stress Developing Countries. *JAMA*. **298**: 1853-1855.



The digital opportunity index for Africa is calculated via the measurement of 11 ICT indicators based on opportunity, infrastructure and utilization. Source: International Telecommunication Union 2005/2006.

A further challenge to the success of eLearning is the global system within which it operates. High-income countries have a considerable need for health workers due to demographic change towards older populations, and more will be required during the coming years. The European Union predicts that 2 million health workers will be needed by 2020 and the

United States expects a shortfall of physicians of 20% by 2025^{20,21}. Health workers from low-income countries, especially highly trained workers such as doctors and nurses, are naturally attracted by higher salaries in high-income countries^{22,23}. Qualifications attained through eLearning might be recognized in other countries¹¹. In this instance, eLearning has the potential to enhance health worker migration and it therefore needs to go

hand in hand with incentives for health workers who have earned diplomas through eLearning to stay within the area they have been trained¹¹.

eLearning needs to be embedded within a health system that makes it valuable for health workers to remain in their local communities

eLearning contributes to stabilization of health workers in rural areas during training, and, when there is ownership of training programmes by developing countries, a fit-for-purpose curriculum and a good integration of work and training. But in the long run the challenges are considerable: the broadband infrastructure needs to be improved, substantial funding has to be generated and eLearning needs to be embedded within a health system that makes it valuable for health workers to remain in their local communities.

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No More Stealth In Health

How the general public strive to create a harmonious partnership with the pharmaceutical industry

Calypso Montouchet, Imperial College London Alumni

Over the past decade, modern communication technologies have armed patients and carers with the means to make demands from the health care industry. In particular, the pharmaceutical industry has been under heightened scrutiny following a string of high-profile scandals, and a widely held belief that research and pricing mechanisms for drugs are at best obscure, and at worst ruthlessly profit-based.

Current growth in online services and technology will increasingly give individuals the tools to demand more information, transparency and accountability from pharmaceutical companies, through expanding choice and engagement with health services across the board. Although positive for both the industry and consumers alike, this evolution should be supported by efforts to improve general understanding of the pharmaceutical industry, the challenges it faces, the subtleties of interpreting scientific data and the fallibility of information found on the Internet.

In November 2010, WikiLeaks collaborated with some of the world's leading newspapers to reveal excerpts of diplomatic cables from top US officials, thereby demonstrating the undeniable power of the Internet to disseminate information and materials hitherto out of our reach. Similarly, within the healthcare industry, untrained individuals can today consult various websites before meeting with healthcare professionals, and patients can use online resources – government-supported or otherwise – to cross check a diagnosis or

the side-effects of the drugs they are prescribed. In addition, individuals are increasingly shopping around both at home and abroad to find the best value for money and the highest quality of services available.

There has been a growing sense amongst the general public that pharmaceutical companies should be more transparent and accountable to those receiving drugs and paying for them. Many deem drug prices excessive – yet little information is available about the massive

Pharmaceutical companies are increasingly willing to display the results of key trials on their websites promoting specific drugs, but often fail to reveal the results of less favourable ones

sums invested at the research and development (R&D) stages that may justify these costs. Pharmaceutical companies and, equally importantly, governmental agencies can provide clarity by being more transparent regarding

the pricing and reimbursement mechanisms that govern the industry.

Furthermore, governments that work alongside pharmaceutical companies to determine drug prices (e.g. Japan, France and Spain) could be more forthcoming with information on how prices are set – and the extent to which said prices take into account innovation and the amounts of money spent on R&D. The UK National Institute for Health and Clinical Excellence (NICE) has recently opened the doors of its technology appraisals (designed to appraise the use and cost-effectiveness of drugs, medical devices and medical procedures) to members of the public although this fact has not been widely advertised.

Marketing and Apps

The pharmaceutical industry has turned towards scientific marketing as a means to promote the clinical and economic value of its drugs to stakeholders (e.g. clinicians, payers such as government and insurance companies, and patients). Interactive communication tools developed for pharmaceutical companies break down the complex notions often involved in clinical trials and allow users to create customized situations in which the impact of a drug is measured according to detailed parameters. The use of these communication tools is growing, as not all physicians can be expected to consult the vast amount of literature published on an endless array of diseases, and not all payers understand the intricacies of conditions treated and the costly burden of preventable adverse events. Although these communication tools are currently rolled out for healthcare practitioners, one can foresee a day when patients will have the opportunity to use these models as well.

Pharmaceutical companies have also been developing applications – or apps – to help demonstrate the clinical value of their drugs to patients. These apps, addressing conditions as diverse as multiple sclerosis and atrial fibrillation, can currently be found on about 5% of smartphones – a percentage that is expected to rise to 30% by 2015¹. While many of these will promote prevention to the same extent as current ‘lifestyle drugs’, some will be used to increase adherence and proper use of drugs with complicated dosing regimens. The general public may thus use apps as an alternative as well as a support for treatment regimes.

Hence, armed with information concerning the efficacy and cost of treatments, the general public increasingly has the tools to be aware of a range of health-related issues and be involved in medical decision-making. These tools can also be used for advocacy: in 2009, the British public resorted to the Internet and the media after a NICE recommendation failed to support the use of Lucentis (a Genetech drug for the treatment of wet age-related

If teenagers today can be expected to grapple with derivatives and tackle Plato’s shadows, they can surely be taught the basics of statistical tests and theories that will be useful to them in assessing randomized control trials, market analyses or biochemical assays

SUNDAY EXPRESS



Several Sunday Express headlines have been lambasted by science columnist Ben Goldacre for being grossly inaccurate and misleading

macular degeneration) until after patients had lost the use of one eye². More than 20,000 thousand responses were gathered until NICE reversed its original decision.

Those Dreaded P-values

Clinical trials are particularly crucial in the pharmaceutical industry, as they can render the millions (\$802 million in 2001, compared to \$318 million in 1987³) spent on developing a drug worthless with a single, non-statistically significant p-value. Pharmaceutical companies are increasingly willing to display the results of key trials on their websites promoting specific drugs, but often fail to reveal the results of less favourable ones, yet they have been widely encouraged to do so^{4,5}. Moreover, while the results of clinical trials are accessible to university researchers, students, and those willing to pay for the journal articles, they are not within the reach of many of those taking the drug whose efficacy is assessed.

Newspapers play a part in communicating the results of certain studies, but their simplifications range from

- [1] Business Week (2011) Mobile Health Apps Arrive. [online] Available at: <<http://www.businessweek.com/magazine/mobile-health-apps-arrive-09292011.html>>
- [2] Royal National Institute of Blind People (2009) Access to AMD Treatment. [online] Available at: <http://www.rnib.org.uk/getinvolved/campaign/your_sight/amd_campaign/access_treatment/Pages/default.aspx>
- [3] Seget S. (2005) *Pharmaceutical Pricing Strategies: Price Optimization, Reimbursement and Regulation in Europe, US and Japan*. Business Insights.
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- [5] Davidoff F et al. (2001) Sponsorship, authorship and accountability. *The Lancet*. 358(9285).

dramatic sensationalization to the inaccurate translation of complex statistical assessments. Furthermore, the proliferation of blogs and websites that involve limited fact-checking, allied to the publication of poorly supported allegations, precipitates further misunderstanding. Members of the general public are likely to be ill-equipped to deal with the increased depth, breadth and diversity of the information available to them.

One such scenario arose when the results of a study⁶ conducted by Andrew Wakefield in 1998, which was later discredited, led to the belief that Measles, Mumps and Rubella (MMR) vaccination caused autism. This led to the subsequent decision of parents across the globe to not vaccinate their children. An epidemic of measles ensued in countries until then believed free from such past concerns including but not limited to England⁷, France⁸ and the US⁹.

The Internet and media played a central role in spreading these claims amongst individuals lacking the background knowledge to accurately assess the information they were receiving, but with enough decision-making power to endanger entire communities' health. Since then, measures aiming to improve scientific practices and reporting have been put in place. For example, the Science Media Centre was established following the MMR controversy to facilitate interaction between the UK's scientific community and the national news media, and ensure that such miscommunications would not be repeated.

Rather than relying solely on the media, however, improved basic epidemiologic and statistical education may help people digest competing information from

diverse sources in the future. Articles outlining trends – for example on the effect of a given drug on disease progression or the impact of a certain risk factor on behaviour – are often translated into user-friendly articles which fail to address basic notions such as p-values and confounding variables (variables that correlate with both the variable whose effect is studied, e.g. risk factor, and the variable upon which it has an impact, e.g. the outcome of the study).

If teenagers today can be expected to grapple with derivatives and tackle Plato's shadows, they can surely be taught the basics of statisti-

cal tests and theories that will be useful to them in assessing randomized control trials, market analyses or biochemical assays. Crucial elements for consideration might include:

- The exact phrasing of the hypothesis. For example, demonstrating a drug's superiority is harder than supporting its non-inferiority.
- The p-value for results including primary and secondary outcomes, as well as the sub-populations in which p-values may differ.
- The adjustment for confounding factors to ensure, for example, that one does not attribute obesity to a poor education so much as to a low socio-economic status – which decreases educational achievement as well as the intake of healthy food, the latter of which is undeniably responsible for obesity.

Armed with the right information, patients can confidently engage with their medical practitioner and play a role in assessing treatment options.

Spreading the Risk

Recent scandals have highlighted certain companies' lack of responsibility regarding publicization of the potential adverse effects of their drugs. Patients and payers find themselves increasingly unwilling to pay for treatments, which may, like Mediator (an obesity drug from Laboratoires Servier), have been flagged as potentially dangerous by conscientious healthcare professionals but ignored

In situations where payers were unwilling to shoulder the costs of expensive drugs with unconvincing clinical benefits, risk-sharing agreements have been developed ... in which pharmaceutical companies are willing to compensate if drugs fail to demonstrate a significant clinical benefit

[6] Wakefield A. J. et al. (1998) Ileal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children. *The Lancet*. **351**(9103): 637-41.

[7] BBC (2011) Measles outbreak prompts plea to vaccinate children. [online] Available at: <<http://www.bbc.co.uk/news/health-13561766>>

[8] Le Figaro (2011) L'épidémie de rougeole en France inquiète les experts. [online] Available at: <<http://sante.lefigaro.fr/actualite/2011/04/08/10818-lepidemie-rougeole-france-inquiete-experts>>

[9] Grady D. (2011) Measles in U.S. at Highest Level Since 2001. *The New York Times*, May 2008.



iPhone apps such as this one for diabetes can help patients adhere to complicated treatment regimens

until the media drew attention to it. Lawsuits are one way of tackling under-performing drugs' ill effects, but they themselves are costly and usually ineffective.

An alternative to these includes risk-sharing agreements, which promote patient access to drugs and remuneration of pharmaceutical companies. In situations where payers were unwilling to shoulder the costs of expensive drugs with unconvincing clinical benefits, risk-sharing agreements have been developed in order for payers to share the 'efforts and risks associated with the development of new medicines' and the 'regulatory, financial and commercial risk of managing these medicines once they have reached the market'. These schemes are few and far between, but despite their flaws (including high administrative costs, and legal complexity), they could pave the way to more widespread scenarios in which pharmaceutical companies are willing to compensate payers if drugs fail to demonstrate a significant clinical benefit.

Your Health in Your Hands

With the dawn of the Information Age, the power to choose increasingly pervades all areas of life. This is also true for the healthcare industry, as people demand more information to make better decisions and

influence policy and drug purchasing on a national level. The inherent complexity of clinical data, and the risks associated with misinformation on the Internet, however, raises challenging questions about the responsibility for dissemination and interpretation of information in this area.

As a consequence of these issues, the pharmaceutical industry has begun to engage with the consumer through websites, user-friendly models and apps, as well as developing risk-sharing agreements in an attempt to involve payers and decision-makers in pricing. Investment in education (e.g. interpretation of statistical tests, awareness of the Internet's fallibility) may offer the next generation an opportunity to engage more directly with medical practitioners and cutting edge research in choosing treatment options.

The information is out there; your health is in your hands.

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Global Health & Human Security In 2012 and Beyond

Julie Balen, Imperial College London

The strengthening of response preparedness for global health threats has gained increasing attention on both public health and security agendas. Since the end of the Cold War, a majority of new wars have taken place within, rather than among, nation states and it has become increasingly clear that people cannot be protected solely through military defense of national borders. Similarly, an improved understanding of human development has highlighted numerous neglected insecurities that are faced daily by poor and marginalized individuals and communities. Increased globalization has also generated new risks and vulnerabilities, not only for those in developing nations, but for all, in a growing and ever more interconnected world.

The human security framework offers a novel approach for addressing various global issues, including global public health, that have stemmed from an imbalanced focus on economic development alone. It enables the development of people-centred initiatives, sound policy formulation and implementation, and a solid basis for international co-operation and multi-sectoral partnerships. Besides highlighting the problem of resources, this article also examines some of the issues and challenges that states and societies face as they respond to the multiplicity of problems related to global public health and human security.

Globally, over the past 30 years, three major trends have provided context for the re-emergence of the human security concept. These are: (i) new types of conflict; (ii) poverty; and (iii) rapidly increasing

globalization. As a result, the scope of the security field has expanded from a narrow 20th century emphasis on national interests and inter-state conflict, to a broader 'global' focus of securing the well-being of individuals and communities.

Human security is seen to complement state security, enhance human rights and strengthen human development, seeking both to protect people against a wide

range of threats and to empower them to act on their own behalf. Although the human security and human rights frameworks share a common value-base, the latter, whilst largely accepted, has lacked political power. Similarly, while human security and human development are linked, they are not synonymous; human development is a broader concept, defined as a process of 'widening the

Human security is seen to complement state security, enhance human rights and strengthen human development, seeking both to protect people against a wide range of threats and to empower them to act on their own behalf

range of people's choices'; whilst human security means that people can 'exercise these choices safely and freely'.

With evident roots in Enlightenment that can be traced as far back as the 18th and 19th centuries, if not earlier, the human security concept is not a historical anomaly. Conversely, an excessive narrowing of security thinking occurred during the course of the 20th century, linked perhaps to the extremely violent nature of the century and its 'deep addiction to war'.

With an increasing worldwide recognition of the political, economic, technological, social and environmental interdependence among nations, and the inter-linkages among the world’s people, the human security approach provides scope for stronger integrated responses, by fostering both global and local identities. It promotes increased collaborations with international and multilateral organizations and, rather than simply relying on the nation state, human security calls for combined, holistic action by all sectors of society, although obligations among them vary.

Furthermore, while the state remains the primary producer of security, it is not a primary referent – power becomes re-distributed upwards and downwards from the sovereign state level. This is most clearly visualized by an exponential growth in civil society organizations and a monumental rise of trans-national companies and organizations, such as the World Bank, as well as regional development banks and organizations.

Although it has its shortcomings, human security, due to its comprehensive nature, is well equipped to capture the importance of addressing salient public health issues in today’s world. Health is a fundamental right of every human being and improving health globally is a key element of any strategy aimed at combating poverty and promoting development, as evidenced by its central focus in five out of the eight Millennium Development Goals (MDGs). Good health is also an intrinsic component of human security, and an instrumental tool for human security, by enabling a fuller range of human functioning, choice, freedom and equitable development.

While a common definition of global public health security may still be lacking, for those who understand it as it is presented in the United Nations Development Programme’s 1994 Human Development Report, the concept is compatible with a primary healthcare approach, emphasizing community involvement, self-sufficiency and protection of vulnerable groups such as pregnant women and the poor.

Strengthening Health Systems

Functioning health systems are the bedrock of global public health security. Their objective is to provide the highest level of health protection and healthcare across the population and to act as the first line of disease surveillance, for both infectious and chronic diseases. However, health systems can become rapidly overwhelmed. Additionally, more often than not, the power of modern health interventions, tools and technologies is simply not matched by the power of local systems to deliver services to those in greatest need, in a comprehensive way and on an adequate scale. Health systems are highly context-specific, and hence there is no single set of best practices that can be put forward as a model for best performance. However, they can be studied in terms of how they are regulated, governed and funded, and how services are provided, accessed and utilised.

Weak health systems disproportionately impact the poor, as they are given less respect, less access to information, less choice of providers and lower quality amenities. Indeed, a lack of access to healthcare, as well as disparities in quality of care provided, magnify social divides between males and females, rich and poor families, urban

Human Security

Proponents of Human Security challenge the traditional notion of national security by arguing that the proper referent for security should be the individual rather than the state. The United Nations Development Programme’s 1994 Human Development Report argued that insuring “freedom from want” and “freedom from fear” for all persons is the best path to tackle the problem of global insecurity. It argues that the scope of global security should be expanded to include threats in seven areas.



Economic Security

Access to a secure income/employment, fair pay and conditions, housing, services

Food Security

Physical and economic access to food

Health Security

Access to preventative/curative medicines and services, nutrition, clean water, clothing

Environmental Security

Policies and practices to ensure sustainability and protection of land, air, water, etc

Personal Security

Safety against threats of violence, crime, war, abuse

Community Security

Protection of community groups including family and ethnic groups

Political Security

Provision of Human Rights, the right to vote and express political views

and rural areas, and indigenous and non-indigenous peoples and, by extension, ensure the continued impoverishment of those who are denied health services.

Factors contributing to weak health systems include a lack of resources and poor health infrastructure, resulting from under-investment or because the existing infrastructure has been damaged or destroyed by armed conflict or natural disasters. In addition to financial limitations, health system constraints such as shortage of health workers and support staff, and weak supply-chain management, significantly hamper the implementation and expansion of health interventions.

For example, there is presently an estimated shortage of 4.3 million doctors, midwives, nurses and health support staff worldwide. Other major challenges include inadequate payment, motivation, training and supervision, as well as poor working environments. Furthermore, while appropriate local health information and data often do exist, they are often not utilized by policy makers or policy analysts, either because they do not have access to the information or because the appropriate data has not

*She needs access to good natal care,
her baby's survival depends on it*



been used to answer important questions about health system performance.

Health system strengthening is a long-term continuous process of implementing effective changes in policies and management within the health sector. It requires both technical and political knowledge, and sustained action. While a majority of the now-developed countries built up universal services from a patchwork of public, private for-profit and charitable providers, this challenge now exists for many developing countries. The urgency of this matter is apparent, since the effectiveness of international collaborations, partnerships and networks, whose role it is to identify and respond to disease outbreaks in the coming decades, depends on the alertness and response capacities of the weakest health systems.

The 4 Es: Efficiency, Effectiveness, Equity and Evaluation

Recent studies have indicated that reducing bureaucracy by streamlining management, increasing cost-effectiveness, and improving efficiency through re-organizing services, decentralizing, and allocating resources to better address the needs of the population, result in sustainable strengthening of a health system.

Vast improvement can be achieved by introducing standards, norms, accountability and transparency, through international health law, ensuring rapid public-private responses, and sharing and translation of available knowledge. Apart from increased international and regional cooperation, it is essential that strengthening health systems also includes better targeting for budget allocation – available resources are not always optimally allocated, as funds tend to be directed to high-tech and high-cost curative services that benefit a select few in urban areas.

Similarly, for the human elements of capacity building, key constraints related to health worker staffing, quality control, infrastructure and logistics must be addressed, including ensuring high standards of safety, comprehensive bio-risk management and expanded health worker training. From the technical and operational angles the focus must also extend to laboratory infrastructure, technology/equipment use and maintenance, bio-specimen storage and transport and access to reference strains for specific diseases.

Global Health as a Global Public Good

Research is a critical part of any effort to improve global public health. Local research capacity strengthening is

indeed a vital tool in developing local ownership and improving long-term sustainability of any health project. Biomedical and technological innovations cannot improve people's health without research to find out how to apply the new products and technologies within diverse political, social, economic and environmental contexts. There is also a need to undertake research on social interventions aimed at improving public health – for example, those aimed at housing, welfare, employment, fiscal, transport and other policies and interventions – forming part of the cross-disciplinary fields of political epidemiology and social epidemiology. Moreover, functioning local health systems require good communication and transportation networks.

Research for health can make a major contribution to global public health security and, more generally, to global development agendas. Evidence-informed health policy that will maximize the synergies between research and policy is dependent upon generating improved ways of priority setting, as well as advances in problem-based planning and resource allocation. In moving forward, evaluation of existing health systems is an important step toward identifying capabilities, critical gaps, and areas where local, national and international priorities overlap. It is vital for countries to now move beyond pure rhetoric, and to participate more fully and more seriously in the principle of a global public health security regime – the One World & One Health – utilising a global public goods (GPGs) approach.

A GPG is defined as having non-excludable, non-rival benefits that cut across borders, generations and populations. Each nation's capacity to prevent and manage public health emergencies, and to take part in joint initiatives with other countries, is vital to decreasing health vulnerabilities, increasing health security, broadening partnerships and building diplomatic relations. A global approach takes into account that diseases do not recognize national boundaries and as a result policies and some interventions need also transcend political borders.

With the goal of human security in mind, the global community is now faced with novel opportunities, as well as challenges, in moving beyond the health securitisation rhetoric to improving health for all

Treating public health as a GPG implies that society must ensure that the value of health is understood as a key dimension of global citizenship and keep it high on the global political agenda, as the provision of global public goods should have priority over national and sector-specific interests. Hence, there is a need to build and maintain a sense of global community, commitment and partnership. Indeed, approaching public health security within a context of collective global solidarity enhances the security of all. Global public health efforts are likely to flounder unless, and until, nation states cooperate in combining their national interests with a more inclusive GPGs approach, in order to provide more efficient and sustainable policies and strategies.

A Framework for the Future

Recently there have been new attempts to embark on a debate as to which values should drive global public health action. These values are reflected in discussions around the impact of globalization, human rights, global public goods, global solidarity and global social contracts. Whilst connecting health more directly to the self-interests of states in security, economic well-being and development has been a necessary starting point, it is not a sufficient step along the road to greater global public health security.

The global public health security concept may provide a new way of working collaboratively and sustainably towards a common goal, embracing human rights and well-being, rather than only enlightened national self-interest. With the goal of human security in mind, the global community is now faced with novel opportunities, as well as challenges, in moving beyond the health securitization rhetoric to improving health for all. There is now a unique opportunity to build upon and strengthen existing health systems using a human security framework, in order to improve the organization, resource management, technical guidance, monitoring, evaluation, capacity and overall mechanics of health care. This is ultimately where the key challenge exists – from *establishing* the global public health security framework to *operationalizing* it.

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The Village that Sells Sex

Priya Garg, Imperial College London

India's absence of appropriate sex-education, continued gender bias, low literacy levels and inadequate job opportunities has allowed prostitution to become a form of employment for many of its lower class, including minors.

Uncovering startlingly minimal levels of reproductive-health awareness, homemade abortifacients, alcohol-abuse and HIV ignorance through personal interviews, the barriers to uptake of current government health initiatives for sex workers are clear.

For a country on the brink of an HIV epidemic, these issues urgently need to be addressed. Remaining a mainly patriarchal society, implementing a public health structure with the onus on male social education alongside teaching of sexual health to both genders will prove vital in stemming the tide of sex-related ignorance that has been allowed to pervade every rank of Indian society. This will subsequently shape the treatment, attitude to and long-term prospects of its poor.

What would you do if the only option for survival was selling your body, confidence and dignity? What if the man who bought you from your parents, took your virginity and then drove you to appointments every night with other men who would force you to perform sexual acts for money?

Using first-hand interviews with prostitutes and their 'fixer' Didi based in a colony on the outskirts of Delhi where, shockingly, almost all women are sex workers, the sexual health myths, violence and secrecy that continue to surround this age-old employment are exposed.

Delhi's Red Light Districts

Young mothers in Delhi, struggling to feed multiple children, are often forced into prostitution through desperation, with yet others condemned to it from birth. India, a dichotomous booming powerhouse of the world's economy, is crippled by pockets of corruption which are sheltering vast 'sex-worker colonies' in its infamous red light districts.

Sex work itself in India is not technically illegal – Indian law does not punish the act for persons over 18 years. Yet, according to the 'Immoral Traffic

Prevention Act,' brothel-keeping, public soliciting or seducing for prostitution are considered to be an offence¹.

Girls begin working after 'marriage' ... boys of the area would purchase a wife from a nearby village for several thousands of rupees and bring her home to start earning income. They would then aid their 'wives' in meeting clients

- [1] Financial Intelligence Unit, Ministry of Finance, Government of India (1956) *Offences Under the Immoral Traffic (Prevention) Act of 1956*. Part B: Paragraph 4.
- [2] Nair P. M. & Sankar S. (2005) *Trafficking in Women and Children in India*. New Delhi: Orient Longman.
- [3] Child & Women Abuse Studies Unit, London Metropolitan University (1999) *India: Country Data on Prostitution and Trafficking in Women and Girls*.
- [4] CNN International (2009) More than 1M Child Prostitutes in India [online] Available at <<http://www.edition.cnn.com/2009/WORLD/asiapcf/05/11/india.prostitution.children>>
- [5] Joffres C., Mills E., Joffres M., Khanna T. et al. (2008) Sexual slavery without borders: trafficking for commercial sexual exploitation in India. *International Journal for Equity in Health*.

There are 70,000 registered Indian sex workers², yet other estimates place that figure closer to 10 million³. Many are trafficked from Nepal and Bangladesh, tricked into fake marriages, stolen from their home or sold by their families. Federal police estimate 1.2 million to be children⁴. Some can be seen on Mumbai's roads in 'zoo-like' cages – they are slaves clinging to filthy iron bars. Inducted into a brutal, degrading way of life from an early age, they become shadows of their former selves, devoid of functioning and subjected to ritual rape.

Heavy-built and in bright traditional dress, Didi – or 'sister' – professed her job to be a local social worker. In fact Didi 'assisted' in fixing up the sex workers with their clientele, and was reticent to allow interviews of her charges unsupervised. In a cattle and muck strewn street, Didi thrust five stools into the middle of the road as mosquitoes encircled, ordering the women to sit and questioning to begin.

Traded as Children by Children

Didi noted that professional prostitution began in 1982, when nomadic tribes settled. Now, 85% of females in the colony are sex workers. Girls begin working after 'marriage', which Didi maintained was over 16. On reaching 13, boys of the area would purchase a wife from a nearby village for several thousands of rupees and bring

her home to start earning income. They would then aid their 'wives' in meeting clients. The women would remain in the job till sixty, after which they would become beggars.

It was clear that parents who sold their daughters discharged their familial responsibility as soon as the child was removed. A dowry paid to the girl's family ensured that the only attachments the girl would have were her adoptive husband and his family, or fellow sex workers. The women would then work for the rest of their lives to pay back the money spent on them. This type of 'marriage' forms the basis of a loophole in the enforcement of human trafficking law⁵.

One sex worker stated that she began working at 14, although mused that she wasn't sure, saying "I'm not even sure how old I am", guessing it to be 45. She was from a neighbouring district but had been here since the 1980s.

Didi contested that 'of course' the women were happy to do this job: being greedy for money, she said that this job allowed them 'quick revenue'. A middle-aged sex worker shook her head in disagreement, but despaired "but what other job would I do now?" A lack of education, freedom of choice and job opportunity had left her trapped.

Girls begin working after 'marriage', with their new 'husbands' aiding them to meet clients and repay their dowry





A lack of education, marital freedom and job opportunities leave sex workers trapped

Class and Clientele

Due to neglect of girls, infanticides and feticides, there is a comparative surplus of men in India. Advocates of prostitution propose that, without it, this male-female discrepancy would lead to 'mass rape of unmarried girls' by sexually frustrated young men⁶. This ideology only serves to promote abuse of lower-class women as a form of 'protection' for the wealthy against the country's more sexually deprived.

Didi confessed that customers come from all social strata including businessmen, truck-drivers, soldiers, farmers and students. Irrespective of rank, the determining factor was adequate cash-in-hand. Women would roam the main highway in groups, finding clients on the road, 'servicing' up to five men a night for as pitiable a profit as 100 rupees per person (£1.50). The fee is based on the sex-worker's age.

Transactions boomed in particular during the 2010 Commonwealth Games.

Due to a surplus of foreign clients, sex workers were driven to high-class hotels by their husbands to supply

demand. Campaigners suggest that during the Games prostitution gangs, using escort agency titles as a front, purchased thousands of extra women. According to non-governmental organisations, there was also a huge rise in the number of minors lured by the promise of a job and eventually sold to pimps⁷.

Gender Stereotyping, Fear & Violence

The World Health Organisation states that sex workers are easy targets for brutality due to stigma. 80% of the 200 who enter prostitution per day in India do so against their will⁸. In a society where the value of human life in general is low, a sex worker's perceived worth is miniscule.

When asked about violence, Didi denied its possibility. Questioned about what might happen if a woman declined to perform for a client, Didi retorted, "that would never happen!" Even

when provided with evidence of sex workers who had been physically and mentally tortured by their captives,

Didi confessed that customers come from all social strata including businessmen, truck-drivers, soldiers, farmers and students. Irrespective of rank, the determining factor was adequate cash-in-hand

Didi still refused. “None of these women will fight with their husbands”, she said, “men hold all the power.” A sex-worker disagreed, admitting that she had often felt afraid and would be beaten if she did not agree to a client’s demands. Didi, overhearing, furiously refuted the claim and the worker retracted it immediately.

Throughout their lives these women have been bought and traded like property. Tied by marriage vows of confidentiality, the consequence of leaking ‘family secrets’ is unfathomable. Indeed, they are so downtrodden and repressed, feeling helpless and accustomed to their role in life, that the notion of complaining seems alien.

Research suggests that women are locked, starved, burned and tormented to comply with their dalal’s (pimp’s) demands. One such case is that of 13-year-old Nepali Mira, a brothel worker in Mumbai, who was promised a job as a domestic worker. Duped by her father, she was trafficked, beaten unconscious and, when she would not comply, she was stripped naked and had a rattan cane smeared with pureed red chilli peppers shoved in to her vagina before being raped⁹.

It is clear that amidst India’s growing population and the startling numbers of poor, there exists a persistent stereotypical attitude to gender inequality, coupled with a culture of marital ownership and exploitation of uneducated women. Fuelled by the idea that sex workers somehow enjoy the job due to their own sexual desires,

Throughout their lives these women have been bought and traded like property. Tied by marriage vows of confidentiality, the consequence of leaking ‘family secrets’ is unfathomable

or choose it through avarice, a blind eye is turned to this abuse. There is clearly an urgent need for social education and alternative opportunity.

Some Indian welfare schemes do exist, such as the 2007 ‘Ujjwala’ project aimed at prevention, rescue and rehabilitation for victims of trafficking, which protect vulnerable sub-sections of society and encourage re-integration. Currently there are 96 Ujjwala projects set-up with 58 operational rehabilitation homes, but their impact is as yet unmeasured¹⁰.

Babies, Birth-Control & HIV

In employment where venereal disease is a constant threat, Didi alluded to a HIV-testing facility down the road. However, sex workers did not use it through dread that diagnosis would end their working lives and leave them destitute. However, she professed that healthy eating and sleep prevented the women from acquiring any sexually transmitted infection (STI), and claimed there was no incidence of HIV in the colony.

Figures suggest that approximately 2.5 million people in India are living with HIV and that

the prevalence amongst Indian sex workers is increasing¹¹. Definitive statistics are not available, yet studies suggest that HIV sero-prevalence rates across tested sex workers from Mumbai, Delhi and Chennai are 50-90% positive¹².

While discussing birth control with Didi, it was established the women did not use condoms due to the pain of friction, and hence had no physical protection against the acquisition or spread of STIs. To avoid pregnancy some consumed a mixture of Aryurvedic herbs from the chemist. However, Didi assured that as the sex workers often suffered from tuberculosis (TB), this greatly decreased their chances of pregnancy.

The sex-worker acknowledged that she had never seen a gynecologist, despite having five children, and was unable to explain anything about HIV, its spread or consequences. She did not use birth control and said that the other workers she knew did not give birth in hospital. A child born to a sex-worker would be delivered through a private local physician.

- [6] Sohni M., Verma N., Narula D., Mathew R. et al. (2008) Missing girls in India: Infanticide, Feticide and Made-to-order Pregnancies? Insights from Hospital Based Sex Ratio-at-Birth over the Last Century. *Public Library of Science*.
- [7] Hodge A. (2010) Girls lured to Games for work sold to brothels. *The Australian*, September 30.
- [8] Hughes D. M., Sporic L. J., Mendelsohn N. Z. & Chirgwin V. (1999) *Factbook on global sexual exploitation*. Coalition Against Trafficking in Women.
- [9] Friedman R. I. (1996) India’s Shame: Sexual Slavery and Political Corruption are Leading to an AIDS Catastrophe. *The Nation*, April 8.
- [10] Government of India, Ujjwala Scheme (2005) [online] Available at <http://www.india.gov.in/spotlight/spotlight_archive.php?id=42>
- [11] Chatterjee P. (2008) Anti-human trafficking law sparks debate in India. *The Lancet*. **371**(9617): 975-976.
- [12] Basu I., Jana S., Rotheram-Borus M. J., Swendeman D. et al. (2004) HIV prevention among sex workers in India. *Journal of Acquired Immune Deficiency Syndrome*. **36**(3): 845.

Didi alleged that it was rare that a sex-worker became pregnant by a client as they usually only bore the children of their husbands unless they needed extra income. She explained that the consumption of a concoction of carrot, water and an unknown toxic substance would easily cause a miscarriage without side effects. The sex-worker would then be back to employment 2-3 days later, with a similar time-period applicable for recovery post delivery.

Many sex workers are attended by unlicensed doctors, while some hospitals have been reported to refuse to treat women who are found to be HIV positive or developing AIDS symptoms out of fear or disgust¹³. Astonishingly, a magazine published in Mumbai argued that AIDS would benefit the country because it would 'depopulate the vast underclass', thus ridding India of its lower caste⁹.

So, according to Didi, despite no use of allopathic contraceptives, there was no incidence of any STIs, including HIV, and little unwanted pregnancy – yet rampant TB. With India succumbing to an AIDS epidemic, currently second only to the Republic of South Africa in the total number of its population living with HIV or AIDs, it is clear the impetus should be on preventative, unprejudiced social action now¹⁴.

Sexual Health Myths

For some, rather than practicing safe sex, HIV testing and treatment, obscure belief in cures for STIs such as washing genitals with engine oil or having sex with a virgin shockingly still persist¹⁵. The latter may in fact have propelled the rise in India's child prostitution rates.

Forced castration of young boys using knives to sever sex organs has led to the creation of some of India's 'eunuch' population⁹. Following castration, artificial female

body parts can be fashioned to pleasure men who hold the view that sex with a 'hijra' (or eunuch) can protect from HIV. Additionally, there are reports of infants with cradle cap being sold to brothel houses: sex with a scalp-eczema-afflicted prostitute is thought to bring good luck⁹.

The sex-worker acknowledged that she had never seen a gynecologist, despite having five children, and was unable to explain anything about HIV, its spread or consequences

Absurd sexual health myths surrounding STIs are perpetrated by inadequate knowledge and sexual taboo. Many Indian schools view

sexual education as a cause of promiscuity and refuse to participate. Such superstition, in the case of both sex workers and their clients, is fuelling dangerous and morally contentious sexual practice.

What is a 'Future'?

'Future' is a word seldom considered by these women. "These women don't think about their future!" Didi explained. "After 30 they lose their bodies and become useless!"

For many, there is no hope of change. A sex-worker wearily offered that she would suffer only humiliation and maltreatment if people discovered her profession. However, she wished her children could go to school, get different jobs and escape the life she had been condemned to. Yet children of prostitutes are rarely able to flee this vicious cycle – in bigger cities such as Mumbai, it is estimated that 95% of the children of prostitutes become sex-workers⁹.

Another sex-worker pointed to her eldest daughter who stood behind her cradling a female infant on her hip. She had begun servicing clients at the age of 14. Due to her young age, willowy frame and long hair, she was easily bringing in money for the family, and had a 1-year-old child in spite of being only 17.

Didi accepted that the main problem for the women of the area was a dearth of alternative employment opportunity. Hence, almost all of the women and girls of the area were still involved in the sex trade, despite a nearby school. She thought that people needed to see rewards for educating their daughters in the form of jobs for them following schooling.

[13] Gangoli G. (2002) Unmet needs: Reproductive Health Needs, Sex Work and Sex Workers. *Social Scientist*. 30(5-6): 79-102.

[14] Knacker L., Varadan S. & Kumar P. (2007) *Study on Child Abuse INDIA 2007*. Indian Ministry of Women and Child Development.

[15] Kumar P. (2002) Myths & Misconceptions among truckers. [online] Available at: <<http://www.gateway.nlm.nih.gov/MeetingAbstracts/ma?f=102253306.html>>

[16] Ministry of Human Resource Development, Department of School Education & Literacy, Government of India (2011) *Sarva Shiksha Abhiyan – A programme for the universalisation of elementary education*.

[17] Chadha M. (2007) Indian state bans sex education. *BBC News Mumbai*, April 3.



Some prostitutes can be seen on Mumbai's roads in 'zoo-like' cages – they are slaves clinging to filthy iron bars

Positive government attempts at 'Education for All' via the 'Sarva Shiksha Abhiyan' scheme are designed to provide free and compulsory schooling up to 14 regardless of caste or creed, yet undoubtedly there are significant obstacles to its impact, including the fact that, by much of society, females are still not seen as necessary beneficiaries¹⁶.

An Urgent Need for Change

The continuation of uneducated, forced prostitution breeds the acquisition and transmission of STIs, promotes large families with mostly illiterate children, the use of risky abortifacients, alcohol abuse, child marriage and sexual and physical exploitation of women and minors.

Clearly a lack of appropriate sex-education, coupled with persistent disturbing myths, leads to dangerous reproductive health practices and the spread of HIV¹⁷. The social education of men in particular needs to be addressed, highlighting gender-equality, human-rights

and the value of learning. Moreover there needs to be an increase in partnership between government-based efforts and NGOs working for the provision of prospects post-school, chiefly for the lower caste.

As an emerging power with burgeoning wealth, India has a unique opportunity to inform its sexually active youth and tackle the AIDS epidemic. A renewed focus on developing a comprehensive school-based sexual education programme, together with the development of educational and employment opportunities for girls born into poor families will help them to escape a life of enslaved sex work.

Unless gender equality, and openness in sexual health and education, is promoted from a young age, there is unlikely to be a move away from exploitation of women such as those in the sex colony, despite India's new position as a leader on the world stage.

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Development of Healthy And Sustainable Cities: A Multidisciplinary Approach

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A lack of proper understanding of sustainable and integrated development amongst government officials and building professionals, particularly in fast-developing regions with high rates of urbanization, is leading to health, societal and economic issues often being tackled independently, rather than cohesively.

The adoption of a multidisciplinary approach to developing healthy and sustainable cities through architectural urban planning and management is needed. This approach aims to raise the awareness of the design professions to the evolving concept of sustainable development, and the interconnected elements required for the development of sustainable healthy cities.

Sustainable development has focused in the past primarily on economics and the environment, described back in 1987 as: "...development that meets the needs of the present without compromising the ability of future generations to meet their own needs"¹

The concept of sustainable development grew during the following decade, with international focus on the issue cumulating in the outcome of the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil, in 1992. The final programme, the so-called Agenda 21, is seen as the 21st Century roadmap for sustainable development for all nations. How does this strategy apply to the design of urban environments?

Most designers refer to the 1987 definition of sustainable development in their design concepts, with architectural design for health developing separately. Indeed, health and social issues are often not prioritised by business and urban design sectors, although

most policies, such as Agenda 21, Health for All² and WHO Healthy Cities projects, have included and emphasised the desire to integrate these factors in addition to creating economically sustainable development.

The WHO Healthy City project suggested a conceptual model of sustainable development on the basis of equilibrium, livability, and sustainability of relationships between environmental, economic, social factors, as well as integrating healthy sustainable development³. This model was further referred to in the later European Sustainable Development and Health Series^{4,5}. This concept, adapted from the WHO models, is applied here as an alternative design approach to the building of sustainable cities through environmental and medical sciences, technologies, urban design, engineering and urban management.

Urban Design

Health and sustainability should be employed in town planning and urban design at project conception. City orientation should be analysed taking into account with the sun path and wind direction for the latitude in

- [1] Bruntland G., ed. (1987) *Our common future: The World Commission on Environment and Development*. Oxford: Oxford University Press.
- [2] WHO (1992). *Health for all targets – the health policy for Europe*. European Health for All Series, No. 4.
- [3] Hancock, T. (1996) *Planning and creating healthy and sustainable cities: the challenge for the 21st century*. In: Price, C. & Tsouros, A., eds. (1996) *Our cities, our future: policies and action plans for health and sustainable development*. WHO Healthy Cities Project Office, Copenhagen.
- [4] WHO (1997) *Sustainable development and health: concepts, principles and framework for action for European cities and towns*. European Sustainable Development and Health Series, No 1.
- [5] WHO (1997) *City planning for health and sustainable development*. European Sustainable Development and Health Series, No. 2.
- [6] UNHABITAT (2008) *Improving urban planning through localising Agenda 21: results achieved in Bayamo, Cuba*. SCP Documentation Series, Volume 6.
- [7] Capurro, A. F., Zellner, M. L. & Castillo-Chavez C. (1998) *Public Transportation and the Transmission of air-borne communicable diseases*. Documento de trabajo N° 20. University of Belgrano.

question, with buildings and landscaping designed and orientated correctly to maximise the air quality and potentially reduce traffic accidents.

Guidelines from Agenda 21 should also be implemented when improving urban planning of existing cities. Urbanisation in Bayamo City, Cuba, over the past 60 years had led to a disorganised and spontaneous expansion of the city that could not keep up with its rapid population growth. However, inspired by the Local Agenda 21 initiative, the city has adopted new planning approaches to develop non-motorised urban mobility, improve municipal waste management and enhance river water quality through integrated hydrographic basin management⁶.

Zoning analysis for industrial, residential, commercial and public areas including parks, hospitals, offices and schools should take into account geological, meteorological and ecological factors. In the planning of industrial zones and waste treatment sites, for example, such analysis would help through reducing air pollution from the secondary source reaching residences. Sustainability can also be gained through appropriate zoning that optimises travel routes to balance energy consumption and pollution concentrations in built-up areas.

Site and building history should be examined for sources of potential contaminants (i.e. previous petrol stations or landfill sites) and should also take into consideration geological factors (i.e. radon concentrations). Pollution prevention and mitigation measures in addition to Environmental Impact Assessments (EIA/SEA) should be integrated into the planning strategies of city developments.

Traffic and circulation are major criteria taken into consideration in urban planning for which analysis of meteorological factors should be considered. Policies on pedestrian and vehicle zones should not be based on only commercial locations, traffic control and wind direction, but also other factors such as, air pollution dispersion, temperature, humidity, and possible weather conditions.

It is also important to recognise the impact of transport on the spread of communicable diseases. For example, using epidemiological data from various neighbourhoods, researchers⁷ modelled the transmission of tuberculosis on bus networks in Buenos Aires. The model provides a useful framework for understanding the complex interactions of individuals within an urban environment.

We Are What We Breathe

The landscape design of micro- and macro-environments should incorporate meteorological analysis to screen or diminish air and noise pollution from industry and traffic where possible. Public transportation and zoning should seek to minimise pollutant exposures to residences on both local and regional scales. The ratio of terrain to building areas should be suitable to allow sunlight and plants to effectively reduce toxicity in the urban air.

Urban design should make air quality enhancement measures a priority

Urban design should make air quality enhancement measures a priority. The appropriate use of trees, plants, landscaping features and fountains can greatly help improve the quality of the air, removing airborne toxins and reducing noise pollution. Natural daylight can also help reduce concentrations of airborne microbes in cities, whilst trees and earth-berms help filter the air at street canyons and reduce noise pollution.

Pollution control policy, land-use and zoning control, traffic circulation planning and urban management, as well as sustainability, can be integrated into planning legislation as a public health measure. Vernacular architecture, aesthetics, local and ethnic requirements should be also included in the urban planning policy.

Constructing a Sustainable Environment

The effects of urban planning, engineering and management can all have a major impact on individuals' health and fitness levels as well as pollution exposure levels. Providing sufficient properly planned community social, play and green areas can significantly help reduce anti-social behaviour and crime rates, while enhancing a sense of community.

The development of healthy and sustainable cities through architectural urban planning and management under a multidisciplinary approach is needed to create and develop healthy and sustainable cities.

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Accra Invaded

Exponential Rates of Urbanisation Pose a Real Threat to Ghana's Development

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According to the UN Population Fund some 72% of Sub-Saharan Africa's urban population currently lives in slum conditions. Currently seen as an indicator for development, high rates of urbanisation for Africa's fast-developing nations often pose significant challenges in the near term.

Ghana, a West African country bordered by the Gulf of Guinea and lying between Ivory Coast and Togo, is the world's fastest growing economy today. However, population growth and high rates of urbanisation leading to housing and infrastructural incapacity threaten this regional success story.

Following an early sunrise, the Ghanaian capital Accra is transformed into a vibrant, noisy and chaotic hub of activity. Leaving the university district Tesano to the east, the mansions with their barbed wire fences disappear and give way to self-constructed barracks made of mud, untreated timber and zinc roofing sheets. Noxious smoke wafts in between the huts as numerous ash hills signal where inhabitants incinerate litter. Children play amongst rubbish heaps or search for valuable material in the slowly moving sewage water. Crossing the railway bridge over the 'lagune' – the open sewer that locals have romantically named the lagoon – one of the higher income areas of Accra – Abelemkpe – comes into sight, with houses surrounded by high security walls, protecting neat gardens with azure swimming pools.

This juxtaposition between rich and poor is part and parcel of the reality that the rapid urbanisation process has brought to the city.

An IMF Fosterling Back from the Brink

When Ghana gained independence from its colonial power – the United Kingdom – in 1957, it was the first Sub-Saharan country to do so, and the future looked promising.

It subsequently played a leading role in pushing forward the process of decolonisation of the African continent.

However, corruption and internal military strife proved

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to be intractable problems, and Ghana went through an extended period of instability in the 1960s and 1970s. Although well endowed with natural resources such as gold, timber, industrial diamonds, bauxite, manganese, rubber, silver, salt and limestone, the 'African economic crisis' of the early 80s also took its toll on Ghana. In less than a decade, the country went from

producing nearly a third of the world's cocoa in 1972 to teetering on the edge of bankruptcy.

It was at this point that the World Bank and International Monetary Fund (IMF) stepped in with a structural-adjustment package to 'rescue' the country's economy. The usually peaceful Ghanaians took to the streets in protest against the drastic measures imposed by the IMF, but since then the country has nonetheless been moving steadily toward political stability and economic prosperity, and seems today to possess one of the most promising futures of any of the West African nations.

It is neither China nor India, but Ghana that has the world's fastest growing economy today with an annual growth rate of 20.15%¹. The republic now has to face up to the side effects of economic growth and the impact of globalisation on the national economy.

Approximately 75% of the inhabitants of more developed regions lived in urban areas in 2009, whereas just 45% of those in less developed regions did so². The United Nations statistics suggest that modernisation and economic progress is positively linked to accelerating urbanisation, but a growing economy does not instantly catalyse an improvement in living standards. On the contrary, population boom and movement to large cities generally puts immense strains on health care systems and creates intense housing pressure.

Urbanisation: Indicator or Hindrance for Development?

What is urbanisation? The general understanding of the term urbanisation describes a movement from rural areas to the big cities, or, citing the most commonly used definition given by the demographer Thompson Warren in 1929, urbanisation is the "movement of people from communities concerned chiefly or solely with agriculture to other communities generally larger whose activities are primarily centred in government, trade, manufacture or allied interests".

However, inconsistencies in statistical description of urban development are widespread. Urbanisation, from one perspective describes the proportion of the population living in cities or towns at a given time across a given area, or from another, indicates the rate at which the urban population is increasing. While the demographics of most developed nations are characterised by a high proportion of urban population, developing nations are often burdened by a high urban growth rate that can – at least in the near-term – pose a significant threat to both the social and economic stability of the region.

Population growth is a major catalyst for issues associated with high rates of urbanisation. As in most of the

Sub-Saharan nations, the main factor involved in urbanisation in Ghana is not rural-to-urban migration, but rather the high natural population increase.

Ghana Invades Accra

In terms of absolute population, Ghana cannot be considered overpopulated. The UK for example has about the same surface area as Ghana, but nearly threefold the population. Hence, the core problem of the African boomtowns is rather the speed of the population growth (2.3% per annum compared to 0.4% in the UK) than the actual number of people.

At the dawn of Ghanaian independence, the percentage of Ghanaians living in urban areas was less than 20%, compared to more than 50% nowadays. With an estimated population of nearly 4 million, Accra is one of the largest and fastest-growing cities in Africa. Again, it is not the absolute number of inhabitants – as is the case in urban agglomerations such as Tokyo and Delhi – that pose challenges, but rather the high rates of inward migration and all the associated consequences. If this process continues at this speed, city infrastructure will not be able to cater for the needs of newcomers. An obvious issue associated with rising population density is housing.

Joel Dogoe, a resident in Accra who knows the city like the back of his hand, describes the housing situation in the capital as follows: "Accra has grown significantly over the past ten years with people now living at Aburi,

Oyibi, Oyarifa and even Doda which are all outskirts of Accra. One of the reasons for this massive expansion is the fact that there are now good roads leading to all these places, so it is possible to live in the suburbs while working in central Accra". Born in the Volta Region close to the Togo border, he has spent most of his life in

The core problem of the African boomtowns is rather the speed of the population growth than the actual number of people, mostly due to the high rate of natural population increase

Accra. His family now lives in a nice two-storey mansion in Cantonment, just a stone's throw away from the American embassy and many other international institutions. "My grandfather told me that where we live in East Cantonment was all bushy when he bought the land to put up this building and today it is Accra's most expensive place to live with costs of about 100,000 US\$ for a plot of land to about 500,000 US\$ to buy a house

[1] UN Department of Economic and Social Affairs (2009) *World Urbanization Prospects: 2009 Revision*.

[2] UN Population Fund (2007) *State of World Population 2007*.

there outright. This is indeed out of the reach for 99% of the Ghanaians.”

Around the world, the quest for better living conditions, and opportunities for education and jobs, continues to attract people to the big agglomerations and cities. The UN² highlights the overall dearth of progress among local, national, and international actors in planning for this influx to urban environments: “Given the economic, social and environmental implications of the inevitable explosive growth of urban populations in developing countries,” “the absence of a coordinated proactive approach is astounding.”

Sodom and Gomorrah

In Ghana, a large number of people who previously worked in the agricultural sector moved to Accra and its surrounding agglomeration in search of a new life over the past couple of decades. This migration, however, led to the construction of informal dwelling areas such as the famous ‘Sodom and Gomorra’, a slum area in the central business district of Accra which held up to 55,000 inhabitants at its peak.

Baptised after two cities mentioned in the Book of Genesis and synonymous with impenitent sin in Christian and Islamic tradition, the Sodom and Gomorrah slum was a result of rural urban migration and war in Northern Ghana. This congested area was not planned for habitation and thus was without basic amenities such as running water, electricity and sanitary facilities.

The present government identifies urban slum upgrading as a priority intervention area to improve lives of the urban poor in line with the objectives of the Millennium Development Goals. While some slums are due to receive a ‘facelift’ in the near future, Sodom and Gomorrah was cleared in 2009

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for environmental reasons and yet other settlements close to the gutters and waterways are presently being pulled down due to flooding risks.

The Railway Dwellers

The plight of the Railway Dwellers from Alajo, situated between Tesano and Abelemkpe, has recently been

In Agbogbloshie (Sodom and Gomorrah) people survived largely by burning electronics to extract copper and other metals



publicised around the world. The term slum for their neighbourhood is not quite accurate since there are many solid structures as well as basic infrastructure including water and electricity. Some are smart and sleek shops or well-constructed residential accommodation, while others are simply shacks made out of nothing more than plywood, old roofing sheets and cardboard. A diverse social mix inhabits the area: a highly competitive housing market in the capital has forced many to seek low cost accommodation including job seekers, farmers, students and even managers.

Will we see an alternative analysis one day, i.e. that low urbanisation will become an indicator for high living standards?

In spring 2011, the Metropolitan, Municipal and District authorities received the presidential order to demolish all unauthorized structures. Already over the past couple of years, the Accra Metropolitan Assembly (AMA) has tried to clear some of the settlements but met with limited success. The clearing of some areas provoked the mushrooming of new settlements as displaced inhabitants had to relocate.

In the case of the Railway Dwellers, demolition would mean total destitution for many. The government is justifying the drastic measures with plans to redevelop the country's railway system, having signed a US\$6 billion contract with a Chinese company.

At a stakeholders' forum earlier this year organised by Amnesty International in Accra, a spokesperson of the Rail Land Association of Abelemkpe, Tesano, Alajo and Achimota pointed out that "housing is a human right" and said AMA presented the issue as if the settlements were mainly slums and residents are illegally occupying the land. In fact, many dwellers pay yearly rent to the Railway Corporation under contract and thus any forced evictions may fall foul of an international legal prohibition on forced eviction⁴.

With the Jan 25th 2012 eviction deadline approaching, it remains to be seen what will become of the Railway Dwellers. They will wake up every morning with the fear of facing the bulldozer for the foreseeable future.

Intangibly Complex Issues?

Confronted with the complex process of urbanisation, policy makers often seem powerless or simply overwhelmed. A broad range of expensive measures are needed to cope with high rates of migration to bigger cities including improved education, contraception campaigns, rural employment and home financing, together with improvements in local governance and infrastructure and coordination between local, national, and international groups. This is a wish list that would gel well with much of the broader development community – but can Ghana deliver?

Prof. Sam Afrane of Kwame Nkrumah University of Science and Technology thinks it can: "We cannot wish urbanisation away. (...) We need a policy framework that allows people to find good housing, access to water and to live reasonably well in our cities. It is possible. It has been done in several countries and we as a country must find the answers to good urban development".

Winds of Change

Today, a high level of urbanisation is often seen as a sign of advanced development. However, what will happen if the economic development can't keep up with the speed of urbanisation? Will we see an alternative analysis one day, i.e. that low urbanisation will become an indicator for high living standards?

Blessing Mberu, a Nigerian sociologist who studies rural-to-urban migration, is not convinced, arguing, "if there is any hope for development in Africa, urbanization must be part of it." But, will Ghana become the next economic boomtown?

Many African investors are attracted to the country, as it is known to be relatively peaceful and politically stable. The economic development of the country is remarkable in the historical and geographical context; however, we haven't seen any global brands from Ghana yet. People in Ghana feel the winds of change, but most remain sceptical. As Joel puts it, "I am not sure we are the next big thing yet."

Franca Hoffmann is currently studying at Imperial College London for her MSci Mathematics, having spent a year in France on exchange. Last summer, she worked with MISE in Ghana offering voluntary mathematics programmes to children.

[3] Amnesty International (2011) [online] Available at: <<http://www.amnesty.org/en/news-and-updates/ghana-railway-dwellers-under-new-threat-forced-eviction-2011-01-27>>



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