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THE ROLE OF EUROPE AND OF INTERNATIONAL SCIENCE AND TECHNOLOGY COOPERATION

Workshop Proceedings
Brussels, 4-5 October 2007

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Table of contents

Executive summary

Rapporteur: Sophie Thoyer

These proceedings gather the written contributions made to the workshop "Responding to global challenges: the role of Europe and international science and technology cooperation" which was organized by DG research on 4-5 October 2007 in relation with the ERA expert group on international cooperation. The conclusions of this workshop were presented at the High Level Conference "The Future of Science and Technology in Europe" that took place in Lisbon, 8-10 October 2007.

The workshop gathered around 30 speakers coming from different horizons (experts, academic researchers, practitioners in NGOs and international organizations). The objectives were fourfold:
- To identify the most important global challenges that research should address in priority in the short to medium term.
- To describe how these challenges have been addressed by international cooperation in science and technology (S&T) in the past, and what remains to be done.
- To assess the effectiveness of existing cooperation mechanisms in S&T and to discuss on the relevance of new – complementary – measures.
- To identify who should be involved in this process.

The workshop was structured as follows: an introductory session was organized on key global challenges. Then specific sessions were dedicated to health and quality of life, energy sustainability and climate change, socio-economic development and food security, agriculture and resources. A conclusive session helped us to draw common conclusions.

Setting the scene

Global issues are gaining greater access on the political agenda of decision-makers. The multiplication of international meetings is a clear sign that the international community is increasingly willing to coordinate national policies and launch international initiatives to at least mitigate the impact of global issues. International cooperation initially focussed on monetary problems (with the creation of the International Monetary Fund) and on trade regulation within the GATT. Development aid policies coordinated by the World Bank or UN agencies were thought out more as rescue plans than as indispensable international policies guaranteeing global welfare. It is environmental issues, more particularly climate change, which has induced a true conversion in the international thinking. It is not anecdotal that the Intergovernmental Panel on Climate Change (IPCC) was instrumental in raising awareness about the urgency of global warming and obtained that climate change be listed as a priority for political negotiations at the international level. The fact that IPCC was the laureate of the Nobel Prize for peace clearly indicates that global warming encompasses broader issues than just the environment. The fact that an international scientific community gets this distinction is also a sign that science has a

role to play and is expected to play an ever increasing role in the management of global issues.

Paul Rogers draws a grim picture of the achievements of the world economic system in the last 50 years. Despite the good intentions of the UN declaration at the end of the second World War, despite the enormous technological progress and economic growth achieved since,, the socio-economic divisions have widened. This is probably one of the greatest failures of our time: a great majority of the world's population that has been largely excluded from the effects of economic success resulting and has been progressively marginalized. As P. Rogers emphasises, "western economic growth was said to embody a "revolution of rising expectations" as people looked towards the consumer benefits of expanding economies….now, the more likely result of the failure of the global economy to ensure socio-economic justice is a potential "revolution of frustrated expectations". This is all the more true that the improvements in international communication, the opening of the Eastern block and of China later, the rising flows of tourism and merchandises have made the rich minority of the world very visible. It exacerbates the feeling of injustice and the lack of trust in political elites and international institutions. It results both in economic-driven migratory pressure as well as in social unrest and radicalisation of social movements. These divisions are likely to be exacerbated by the impact of environmental constraints with the access to scarcer resources (including land threatened by rising sea level) becoming crucial. P. Roger's analysis is that the Western world's response, by concentrating primarily on the security of the North Atlantic countries, is a dead-end because it "seeks to maintain control within a status quo, rather than addressing the problems at root". This "liddism" – keeping the lid on security problems – cannot be an adequate response. The world should adopt instead a "sustainable security" paradigm and address directly the problems of inequities in access to the fruit of growth and nature. It would require substantial resources, but they are commensurate with current military expenditure. It requires the kind of trans-national cooperation for which the European Union has considerable potential.

Susan George explores in more depth the roots of this deepening socio-economic divide. She points out that the Western world has a tendency to make the assumption that its policy choices have only –at most- a benign impact on third countries. However, the desperate out-migration movements reveal that the international crisis is extremely severe and should not be analysed as a "normal" phenomenon but rather with new –critical-eyes on the policies practised so far. She suggests that Europe assesses thoroughly and without pre-conceptions the impact of its past and present choices both when participating to international organizations (the World Bank's orientations on structural adjustment programs, the IMF's priorities on debt, the WTO rules for the liberalisation of trade) and when designing its own policies (the common agricultural policy, the economic partnership agreements with Africa). She explains that the developing countries' chronic illnesses are not incurable provided the Western world accepts to forego a small part of its short-term profits for a longer-term improvement in global welfare. Debt cancellation is a priority: it is expected, if well conducted, to create employments as well as allowing for much higher spending on health, education and other necessities. "It would contribute to job creation in Europe as well, as former debtor countries would begin to be able to

spend on goods, rather than on economically sterile interest payments". The key message to the European Union is that the consequences of European policies on third countries should be carefully assessed: a guiding principle of European action should be at least to inflict no harm on other countries. One conclusion that could be drawn in terms of S&T cooperation is the need to develop shared, reliable methods of sustainability impact assessment, not only in the area of trade policies as it is already practised, but also in the area of environmental policies, finance and international lending, and migration policies. It requires cooperation in research to identify the relevant evaluation indicators.

Dinesh Abrol analyses the conditions under which science and technology international cooperation can help to address the development issues described above. He emphasises that the paradigm of a "competitive" world cannot be a legitimate basis for international S&T policies. Policymakers should view research cooperation with emerging economies and the developing world as a major opportunity for the world as a whole to solve global problems. He shows that emerging countries, such as the BRICS group (Brazil, Russia, India, China and South Africa) are not only willing but also capable to become rapidly equal partners –even competitors- with Europe. The EU must therefore face two challenges. The first one is that it should promote cooperation links rather than competitive links with such countries. D. Abrol insists that the time is ripe for the development of joint EU-BRICS programmes and recommends that the EU be a leader in initiating an international dialogue to promote it. The second is that the promotion of so called "economic freedom" or "neo-liberal policies" when applied to the sphere of science, technology and innovation can impede the way to sustainable progress, at the expenses of developing countries but also of the global world. The EU should shape instruments and mechanisms which defend the practice of pluralism in technological solutions and approaches to development. D. Abrol suggests to expand the technology platform concept, and to promote the "not-for-profit" model of S&T cooperation, for example through the development of open source models for technology development, or the opening-up of the intellectual property right regime. Within this perspective, the EU and its member states could initiate an international discussion on the launching of a multilateral agreement on open access to basic science and technology to respond to global challenges.

Health and quality of Life

The contributions of D**. Sanders and E. Igumbor, F. Barten and C. Ijsselmuiden** converge to underline the urgent need to invest in research addressing the issues of practical health systems development. They emphasize that public and private international funds for health-related research for, in, and with developing countries, are mainly available for a few communicable diseases such as tuberculosis, malaria and HIV/AIDS. However the health crisis in developing countries has much wider and complex roots. S. Sanders and E. Igumbor draw our attention to the fact that there are huge health inequalities and diverging health trends in African countries, which are experiencing both high levels of violence and injuries as well as an emerging epidemic of chronic diseases, usually thought to be confined to the better-off regions of the world. It

therefore exerts a double burden on weak and often deteriorating public health systems. F. Barten also illustrates the multi-dimensional issue of health risks: poor people are exposed to a wide variety of interconnected health risks whose health effects tend to reinforce each other and create multiple disastrous familial outcomes on the capacity to work or educate the children. These risks are greater in big cities "where there is also more exposed informal sector, more pollution, more income disparity, and more gender inequities".

The conclusions of these three contributions are that existing health services and research are often inadequate to address health inequities, and technological solutions are insufficient to address these health challenges. Health systems tend to prioritise single issues instead of an integrated approach of health problems at a local scale; vertical disease-programmes instead of system development; curative care based on a 'symptom-treatment mode' instead of prevention; an analysis of individual proximal risk factors instead of an analysis of the upstream, underlying and structural determinants of population health.

The authors also emphasise two major imbalances in existing health research programmes. The first one is the glaring lack of funding for research focussing on the social, economic and political determinants of ill health and ill-designed health systems. As Sanders and Igumbor put it, **"**it is striking that only cursory attention has been paid to exploring questions about why some primary health care programmes work and others do not, or how to best organize public health interventions to get maximum benefits". The second imbalance is that most of health research which is done for developing countries is not conducted by local researchers or local research institutions. The consequence is the dramatic incapacity to turn international knowledge on pathologies into locally-effective effective health system management.

D. Sanders and E. Igumbor, F. Barten and C. Ijsselmuiden call for a reappraisal of existing priorities in health policies, expenditure and research. They provide a set of detailed and well-argued recommendations on the role that the EU should play for S&T cooperation on health issues. Their most important conclusions are summarized below.

1) Research priorities should be re-oriented to include a broader analysis of the origins of health risks in a trans-disciplinary approach, acknowledging the importance of the socio-economic and environmental context, addressing the needs to design robust health care system which resist financial crisis and preserve equity to health access.

2) Research should be organized on the basis of " responsible vertical programming" (in Ijsselmuiden's words): it must not only deliver innovations and new products but also build the ability of developing countries to use and conduct research, science and technology to become innovators themselves. Good health research systems in low and middle income countries will make international collaboration in science and technology for health more efficient and will benefit both sides. The provision for effective collaborative research should thus be included both in the selection criteria and in the monitoring of funded research programs. Non governmental involvement

should be encouraged and networks of excellence between researchers in 'north' and 'south' could be a way to foster technology exchange and collaboration. The EU could also invest in international information systems on current research programs, research priorities and sources of funding.

3) The EU should adopt a rule of conduct for health research financing based on the three following principles: (i) the "principle of complementarity' between research sponsoring institutions and development agencies in order to optimise the operational outcomes of research; (ii) the 'scale of funding', which must be sufficient both in terms of magnitude and duration to facilitate the building of large joint research programmes. C. Ijsselmuiden recommends that an equivalent to the NIH's Fogarty International Centre (NIH/FIC) be established in the context of international health research "to provide substance and a voice to the need for long-term thinking in collaborative health research with low and middle income countries"; (iii) the 'funding of orphan issues', either because they are too risky for commercial development or because they do not create sufficient benefit opportunities or political interest (areas such as rehabilitation, disability, mental health, environmentally induced health problems, or health system optimisation).

Energy sustainability and climate change

In the area of energy, **Suzanne Dröge and Marianne Haug** insist on the urgent need for more international research on the three goals identified in 2006 by the EU's Greenbook on energy: to develop new sources of energy supply, to improve energy efficiency, and to provide a better analysis of international linkages between economic development, political processes, climate change and national energy security policies. The new priorities should also include a commitment to ensure "access to energy for all".

International S&T collaboration in energy started in the 1950s with the launching of nuclear research programs and later with the development of energy diversification strategies following the first and second oil shocks. But M. Haug emphasises that we are entering a new era of cooperative research based on environmental and social priorities, and more focused on the analysis of energy policy options. Such collaborative research could even constitute one of the pillars of the post-Kyoto policy negotiations. It is thus extremely important for the European Union to play an active part in developing these collaborations. The EU should also be more proactive in drawing in the investments of the fossil fuel industry in order to accelerate R&D on sustainable energy. .

The main research priorities for international cooperation should be the following:

1) A thorough analysis of the restructuration of energy markets in face of major changes affecting supply and demand: the monopolisation of oil and gas supply in some net exporting countries; the progressive integration of energy-related climate strategies and the regional energy supply strategies; the increasing demand for infrastructure

improvement to trade and transport. Scenarios of future energy supply should be drawn both for Europe and for the world.

2) Another important research gap relates to sustainable energy research. **Carlos Young** provides a thorough analysis of biofuels. They have been presented as "win-win" solutions to the oil and climate change crisis: they are the renewable substitute to oil-based fuels, they enhance economic activity in land-rich countries by boosting the agricultural sector, and they reduce emissions of greenhouse gases from gasoline and mineral diesel. But C. Young draws a much grimmer picture and recommends that further research be conducted before promoting biofuels too rapidly. Biofuels affect food prices, because of the displacement of part of agricultural production from food to energy use. It can have massive social effects and trigger social unrest. Moreover biofuel production drives up land prices and increases the pressure on natural resources and on subsistence farming. In Brazil, it indirectly contributes to deforestation –and therefore to global warming - by inducing cattle ranchers to move towards the agricultural frontiers where land prices are lower. Finally, it is not excluded that producing, refining and distributing biofuels be more energy-consuming or emission-intensive than traditional fuels. While it is urgent to get proper estimates of the net benefits of biofuels, there is a glaring lack of studies using consistent and reliable methodologies. All these issues require careful research and should be complemented by cutting edge technology research in 2nd generation biofuels, in carbon capture and sequestration (CCS), and also in the pending issues of nuclear energy.

3) A third priority research area concerns the impact that all these changes will have on domestic economies. How well and how quickly will different societies adopt clean energy technologies? What will be the effects of these, generally more expensive, technologies? What will be the consequences of changing consumption for the 50 countries worldwide that depend significantly on fossil fuels for their revenue?

Such research requires both highly specialized scientists in specific areas of S&T and international pluri-disciplinary teams working together on the resolution of international policy issues, and bringing together their knowledge of national or regional research methodologies and results. M. Haug for example suggests that well-organized exchanges of information could help to bridge the gaps in internationally comparable data availability. She also strongly emphasises that research cooperation is an indispensable step to "promote a dialogue on energy supply that is driven by facts or ideas rather than competition or free riding". The EU can play a leading role in this endeavour, both at the political and scientific levels through for example the Global Bioenergy Partnership and the reinforcement of appropriate instruments such as well-designed research calls.

Socio-economic development

Kevin Gallagher underlines that research should investigate thoroughly its own impact on growth and development: to what extent and under what conditions can S&T policies

be deployed to accelerate economic development and alleviate poverty in an environmentally sound manner? He provides a thorough analysis of the Chinese economic success which is based, amongst others, on a very proactive strategy of S&T development. He also deplores that such growth is achieved at the expenses of the environment at home and abroad. He addresses the question of how developing countries could mimic China's success without falling into the same traps: what are proper institutions for S&T-based industrial development; how to reach the right balance between foreign direct investments and indigenous development; how to import technology through imports and licensing; how to either "start up" a national investment strategy or spur it to "catch up?". One key research need regarding globalization and development in relation to S&T policy is to "fully understand the nature of Chinese development and to examine the extent to which current EU and global economic policy is consistent with such development paths". The conclusions will also be useful to help the EU agencies and private firms to form partnerships with the Chinese S&T system and to engage into mutually beneficial cooperation.

Carole Radoki draws our attention to the issue of urbanisation: how does this major trend in developing countries affect and is affected by poverty and sustainability issues? Since a rapidly growing share of the world population lives in urban areas, it is essential to be able to design policies accompanying this phenomenon. C. Radoki argues that the academic community working on urbanisation needs to shift its focus to analyse the diversity of cities in relation with international influences, as well as historical, economic and physical heritages. Does the emergence and growth of urban agglomerations cause incomes to rise in the long run or are they an outcome of national economic growth? Do economic and environmental costs and benefits vary between large and small urban centres? What drives the dynamics of city economies? What is the role played by the informal sector? These are questions that require further investigations. There is a large body of research but it is patchy, and unsatisfactorily coordinated. C. Radoki therefore recommends that "in addition to funding for new research, knowledge management needs to be encouraged and supported, to enable local researchers to identify questions that are of interest beyond the domestic arena and to avoid duplication".

Food security, agriculture and resource

Peter Gregory and Gilles Saint Martin analyse in details the research needs of the agricultural and food sector. They both emphasise that the world is now facing an acute food crisis characterized by alarmingly low food stocks, soaring agricultural prices and the perspective of structural food deficits looming over the near future. Whereas it contributes to inflationary pressures in high income countries, it has already triggered social unrest and political instability in many developing countries.

The causes of such crisis are complex and were not fully foreseen by the main research institutions working on agriculture. It is a conjunction of several structural changes which have reduced supply and have increased demand at the same time: more droughts and natural disasters associated with climate change worsen uncertainty on harvests. The

rapid income growth and urbanization rate in emerging economies are inducing massive diet shifts towards more animal calories, increasing the need for more animal feed. The steady rise of oil prices and the reinforcement of bioenergy policies to reduce the dependency from fossil energy are redirecting agricultural products towards bio-fuel production. Agricultural markets have also become the new eldorado of speculation and investment funds, and the market volatility is now much greater than the true conditions of production justify. All these factors contribute to making consumers in food-importing developing countries (mostly all African countries) unable to afford the products on sale, although it improves the prospects of their agricultural sectors.

The consequences at stake are considerable and have put back the agricultural sector on the front scene of international concern. They are at the crossroad of many issues: poverty and food security, social unrest and migratory pressure, but also environmental threats associated with the extension of arable land and intensification: deforestation, ecosystem destruction, soil losses, pressure on water resources ton increase irrigation, pollutions by pesticides and fertilizers, risks of zoonotic diseases and epizooties, etc.

Researchers and policy-makers face a double challenge: they have to come up with rapid policy and technological answers in order to respond to this emergency situation; and they must also contribute to build a reformed global agricultural and food system able to tackle the upcoming structural changes. Calls to the international scientific community are becoming more pressing.

The **recommendations** drawn by P. Gregory and G. Saint Martin on the most urgent research topics are the following:

1) Invest massively in agricultural research to develop an "ecologically intensive agriculture. Research has to solve the following equation: to increase agricultural production with techniques and cropping systems which are more resilient to changing climate conditions, which reduce their impact on natural resources and habitats and which are less dependant on non renewable resources such as fossil fuels or extracted minerals. It implies that agricultural production be based on the ecological services that biodiversity and biological interactions naturally provide. It requires a better knowledge of the ecological process of agro-systems and a thorough analysis of the social conditions for knowledge adoption.

2) Increase our knowledge of food systems, from production, to processing, packaging, distribution and retailing. The crisis is disrupting the whole food system. There is a need to understand the technological and economic links between the different stages of food production – both vertically and horizontally across products, sectors and geographical areas. A number of international initiatives already analyse these issues but they could be reinforced and extended. It is the case of the Earth System Science Partnership (ESSP), which initiated a joint project on Global Environmental Change and Food Systems (GECAFS) in collaboration with the Food and Agriculture Organization, the World Meteorological Office and the Consultative Group on International Agricultural Research (CGIAR).

3) Elaborate public policies shaped to reduce poverty and improve food security. Local authorities, national governments and international institutions need to have a clear vision of the role that agriculture could play to reduce structural inequities and poverty. It is essential to improve our knowledge about how consumers, producers and markets adapt in different policy contexts with rapidly changing prices. It calls for comparative studies and the development of prospective scenarios. Combined agronomic and socio-economic models will be increasingly useful to simulate the impact of structural changes and to design adequate policy interventions and regulations.

4) Interact closely with research on the sustainable management of natural resources. In particular, Claudia Pahl-Wostl emphasises that water resources management is a pressing challenge. Water crises are often caused more by problems of governance and ineffective management than by resource or technology problems. Although it has traditionally been considered to be a local or regional issue, water is in fact a global issue and therefore requires international research cooperation: the hydrological system is a global system, exchange processes occur at global level, and consequences (biodiversity losses, erosion, health issues etc.) have global repercussions. Moreover, the driving forces of water-related conflicts often lie outside the reach of local or national governance: for example, rules of international trade indirectly shape competitive pressures on irrigation resources. International initiatives such as the World Water Council and the UN-launched 'Water for Life' decade (2005-2015) try to develop international research networks and to strengthen the capacities of countries for good water governance, cooperation, management, sustainable use and protection of water resources. The European Commission conducted a critical review of its water-related research programmes. On of the major conclusions of the panel was the need for long-term financial support for knowledge systems and decision-support tools, in order to bridge the gap between innovative research and adoption by practitioners. Another recommendation is to promote research in the social science area to improve water governance. This is as important as the search for technological answers to fresh water scarcity.

It is all the more important to coordinate at the international level on priorities that agricultural research is probably the most organised –somewhat over-structured- public research sector in the world. G. Saint Martin provides a thorough analysis of what works and what does not work in the governance of agricultural research for international development. All his conclusions cannot be summarised here but it is worth mentioning at least the three following points on how the European Union could contribute to improve the effectiveness of this research network:

- The EU could promote the more holistic food systems approach in its research planning and policy considerations, both within Europe and internationally (see for example the ESF/COST Forward Look "European Food Systems in a Changing World"). It should also defend the food systems approaches in its collaborations with

international research centres such as the CGIAR. The synergy of the instruments of the different European Community policies can be improved further, and complementary actions defined for common priorities across DGs should be extended. The FP 7 was defined in 2004–2005 when political concern for agriculture was not as intense as today. Its ambition vis-à-vis international cooperation remains limited, with too few specific international cooperation actions, and a budget which is one third of that allocated to the health priority. It is thus important to re-assess the budget allocated to research on food security.

- The EU should maintain its efforts to allow equal participation of all partners in the research activities and to be more proactive in initiatives such as the Global Partnership Programmes or the Challenge Programmes adopted by the CGIAR. It should encourage South-South scientific cooperation, and promote investments in the neglected research centres of developing nations.
- The EU should clarify objectives and conditions of international scientific cooperation. A set of criteria must be defined in order to differentiate the type of cooperation that the EU wishes to undertake with third countries. These criteria should include: the comparative advantages of third countries in terms of science quality, together with the competitive pressure that their agricultural sector could impose on the European sector; the European external policy goals (development goals, global public goods, full association objective with neighbouring countries, etc.); possible interactions with the European agro-farming sector (avoiding scientific cooperation for crops in competition; taking into consideration the interests of the European private sector regarding resources or market access); the welfare of European citizens (food safety for non-competing imported products, for example).

Broader perspectives

Three contributors were solicited to provide a broader perspective on international cooperation in S&T for global challenges. **Viriato Soromenho Marques** advises us to take the right distance with the set of recommendations drafted in this workshop: they can provide useful insights, trigger new ideas, promote different perspectives. However, they are neither exhaustive, nor prioritised.

This is true of course, but the lively debates we had during these two days suggest that there was a true willingness to identify common criteria for setting research priorities. The four criteria proposed by V. Soromenho Marques echo those who were regularly advocated to justify the group's decisions:

- Priorities must address critical and crosscutting areas and domains, with the objective to improve social progress.
- Priorities must trigger multidisciplinary cooperation and cross-fertilisation at all levels
- Priorities need to be coherent with the overarching goals of European Union policies.
- Priorities should focus on services of universal value, reinforcing the global trust in the European Union.

The workshop also helps us to understand that, although we share a common culture for conducting scientific research, we do have different cultural, disciplinary, individual

heritages, and we defend consciously or not different underlying values. What is true at the scale of a small group of scientists, civil society representatives and research coordinators, is much more acute at the international scale and can become a major obstacle for cooperation. However V. Soromenho Marques emphasizes that such diversity of values and understandings of a global issues could also be a source of richer research, provided we resist the temptation to look for an illusory consensus. We'd better build on our divergences rather than brush them under the carpet. International cooperation is the result of a long and strenuous process, not the beginning of it.

Within this perspective, **Alberta M. Sbragia** provides an interesting illustration of the way research infrastructure of the United States has internalized international cooperation. She describes the governance structure of the American Research Area and identifies the main drivers of its success: the strong coordination between federal, state and philanthropic funding; the continuous interaction with the private sector; the highly competitive nature of the University system; its openness to the world including Europe. The American research system provides a comparative benchmark, useful to draw recommendations for the build-up of the European Research Area. A. Sbragia shows that paradoxically the strength of American research is not jeopardised by its decentralisation and fragmentation. It is internationally oriented and it has succeeded to promote the right hybridising level between public and private institutions. Three major institutions in the American research area are emblematic in this respect: (i) National laboratories and technology centres which are under the authority of the US Department of Energy and investigate research questions linked to defence as well as the environment; (ii) the National Science Foundation is an independent federal agency with a particular focus on mathematics, computer science, and social sciences, (iii) the National Institutes of Health play a major role in medical sciences.
A.Sbragia concludes by emphasizing that the diversity of Europe should not be seen only as an impediment. It can also provide the impetus for a dynamic research area. However she remarks that Europe is no prepared yet to accept that funding be directed to the strongest research institutions or countries. The norms of regional equalization and the ongoing enlargement of the EU do not allow an easy transposition to the European context of the "competitive federalism" attitude that has made the success of American research. She therefore suggests that Europe adopts "the goal of a layered research area, in which wealthy research-oriented countries would be given support for the most technologically sophisticated research while the poorer accession states would be given support to build up their long-term institutional capacity". A. Sbragia also suggests that the US and the EU build a common framework to tackle specific scientific issues and invite third countries to join.

Inge Kaul concludes by highlighting the importance of the notion of global public goods. They are increasingly advocated by decision-makers both in international arena and on domestic scenes in order to change perspectives and attitudes with regard to international coordination of national policies. The list of global challenges is long and still lengthening, and includes a vast array of issues, from environmental and social issues (climate change, biodiversity losses, poverty) to global risks (communicable diseases,

financial volatility, international terrorism) and harmonization of norms and standards across borders. As public goods constitute one of the main justifications for state intervention, they are at the center of public economics and finance. I. Kaul reminds us that the global dimension of many public goods is curiously absent from most theories and practical textbooks of public's economics. She therefore suggests that our understanding of global issues and global policymaking is patchy and probably distorted. She calls for a re-foundation of the current standard theory which would include this fundamental dimension of policy-making. It would allow to develop a common conceptual basis and to provide analytical tools which would be more useful to understand the provision path of a global public good, the incentives and motivations to cooperate, the interdependance between public and private inputs, the governance reform needed to improve the links between national and international-level interventions. She advocates a shift from "exclusive policymaking sovereignty" to "responsive policymaking sovereignty", with states taking into account the impact of their strategies and policy choices on the rest of the world.

Conclusions

This summary synthesizes the common points to all sessions by focusing on three cross-cutting questions:

- Why should the EU invest in S&T International Cooperation on global challenges?
- What are the principles which should be mobilized to define priority areas and partners?
- What are the mechanisms that should be reinforced or created to foster international cooperation?

Why should the EU invest in S&T related to global issues

In the Lisbon strategy, the objective of reinforced S&T is to improve Europe's competitiveness in order to foster growth and prosperity within Europe. The green paper on S&T adds an additional dimension: it takes a firm position in favour of an EU-driven strategy which will "make sure that international S&T cooperation contributes effectively to stability, security and prosperity in the world".

We live in a world of increasing interdependencies, all accentuated by the trade and finance liberalization process, the concentration of population in huge cities, social inequities and global phenomena like climate change. We are thus facing increasing **global risks**, both in terms of probability of occurrence and in terms of vulnerability: ie. major breakdown of infectious diseases, irreversible ecosystem destructions, conflicts and terrorism threats, natural disasters due to climate instability, international financial crisis, etc. Such issues have to be dealt with urgently, but, in most cases, uncoordinated national policies cannot provide a satisfactory answer. No matter the efforts made at home, we depend on what happens and what is decided elsewhere.

There is therefore an urgent need for **multilateral collective action**. The first action is to invest in S&T to provide joint technological and policy answers in order to mitigate the impact of global issues. The second action is to mobilize large networks of experts and scientists who can work efficiently together in order to respond rapidly to emergency crisis. The benefits in terms of reduced global risks will be shared by all: it will contribute to the world's prosperity and also to Europe's prosperity. This means also that we need to find ways to overcome the free-riding temptation (let other countries pay the costs of action and enjoy freely the benefits), which could lead to attrition and global inaction.

There are thus three arguments in favour of a strong investment of EU in S&T focusing on global challenges:

1) ***To help Europe to meet its obligations at home and to mitigate the impact of global risks***

Global issues are threatening our lifestyle as well as the world's stability. Global risks are increasing at a speeding rate. Marshalling the necessary political will and resources within the next five to ten years is critical. It is urgent to ensure that S&T is able to deliver workable solutions in a very short time span. Most contributors to the workshop agreed that the EU had no choice but to engage very rapidly into an ambitious S&T program on global issues.

Global issues such as climate change or the spreading of contagious diseases can only be solved through effective cooperation in order to limit free-riding behaviour, to coordinate policy actions and to tailor policies to each country's characteristics. It also requires major investments in research to develop new technologies which can help to address global challenges.

The EU has already signed several international treaties aiming at regulating better global issues such as climate change. It therefore has to **meet its international commitments** without **eroding its competitiveness**. S&T cooperation with other signatory parties is essential to share the costs of necessary adjustment to science and policy. It is useful to highlight that by contributing to S&T on these issues, the EU acts for the benefits of all but also for its own benefit. It can also create major economic opportunities for the private sector because new technologies (alternative energies, plant varieties adapted to global warming, new infrastructure) will meet huge market demands in the next future, both as a result of market pressure (ie the raising prices of fossil fuels), and the coming into force of international binding agreements. It was even argued by some participants that investing in S&T on global issues could play a role by providing the necessary economic push to develop out of economic stagnation.

2) To support policy positions to be advocated by Europe

By strengthening its knowledge of global issues and of potential solutions, the EU improves its capacity:

- to define a common strategy and to confirm common interests amongst member states
- to be more audible in international negotiations. This is particularly crucial when there is scientific controversy on the causes of the global issue at stake or on the solutions. Helping to establish an international epistemic community on this issue is the first step towards a shared strategy.
- to reach workable solutions with third countries on policies related to global issues.

The EU has already undertaken a number of initiatives to push forward the sustainable development agenda. However, if it wants to be **credible** and confirm its reputation, it needs to mirror its intentions and objectives defended on the international scene, into decisions and effective actions taken at home. Adopting a common strategy on S&T addressing global challenges is a strong way to confirm its leadership on global issues.

Thus, a well coordinated S&T IC policy on global issues will help the EU to **participate more efficiently to agenda-setting in international fora**. Being a leader on the international policy-making scene is also a way for the EU to reinforce the bases of its economic competitiveness in the future because it can be more pro-active in the design of international regulations affecting its private sector.

3) To support EU aid strategies

International cooperation on S&T for global challenges must be clearly distinguished from the EU aid strategy. Investing into the provision of global public goods is no philanthropic action. It also creates benefits at home. Therefore aid money should not be diverted from its initial purpose (alleviate poverty and create development opportunities): funds for international cooperation on global challenges must be additional funds. However, **positive synergies will arise between aid policies and S&T policies**. This needs to be investigated. By investing on specific research themes with the right partners - those who can contribute to improve the effectiveness of solutions – aid and research purposes can be jointly attained. For example, a better control of the avian flu cannot be obtained by only focusing on joint research with the most advanced teams on virology. It also requires joint action with countries where the outbreak of the flu is most likely to occur due to poor hygiene and animal health controls. As long as such countries are not associated, research won't suffice. Such countries are called "weakest links" in the global public good jargon because it is their level of effort which limits the success of the whole S&T on an issue such as contagious disease. Since their effort is strongly correlated to their level of income, one needs to coordinate aid programs and S&T cooperation.

Principles and decision criteria to define priority areas and partners

1) Does research on global issues require different criteria/priority?

Global challenges are multidimensional and can only be properly understood and analyzed by **multidisciplinary and integrated** approaches. They are complex scientific challenges, with scientific controversies turning into social controversies (ie the anthropic origin of global warming, the GMO risks); they require a better integration between natural and social sciences; they involve many stakeholders outside of science; they are politically (and economically) sensitive; they raise issues of equity and openness; and critical links must be made between local and global challenges and solutions

There is a need also to address the **policy / incentive side of global issues**. It is an area of research in itself in which **social sciences** should be more solicited. International cooperation is necessary here to understand better the institutional and regulatory characteristics of countries and to design policies which integrate different levels of decision-making. Two types of research have to be pursued together: how to change incentives in order to promote individual behaviour, social and economic organization, which are more compatible with sustainability objectives? How can scientific progress help in reaching these objectives more rapidly, at lower financial, human and environmental costs? It is essential that research efforts be put on those two dimensions together: we need to design policies ensuring that technological answers are made more effective, are readily adopted and do not produce backlash effects.

Gaining a **better understanding of the structure and dynamics of global phenomena** was also pointed out as a crucial research step. It requires interdisciplinary and systemic research, based on a very thorough analysis of facts and primary data. Reliable data base at the world scale have become an essential input into good quality research. The EU should play a role to integrate modelling efforts which are made here and there and provide more reliable, rich, and up-to-date **databases** both on ecological systems and on socio-economic indicators. The EU has its own statistical apparatus but it has to update it to integrate information on new members and associated members. Since the EU has skills in creating standards for data collection, it can be a driving force in this field, together with existing international organizations, in order to create more relevant indicators, useful for decision. It was suggested that a more systematic risk-management analysis of global problems be conducted: by building a comprehensive risk database, by documenting practical successes and failures in dealing with global issues and by conducting an assessment of the human dimensions of global change (captured by richer indicators than just GDP), more relevant cost-benefit analysis could be conducted of existing policies. This would foster a more rational debate about policy choices dealing with global issues

Another question concerns the organization of collective action for research. **Do all research area require the same model of international cooperation?** By analogy with the literature on global public goods, we can suggest to distinguish three forms of S&T cooperation, according to the type of knowledge, innovation and technology required.
For some research issues, the knowledge production function is additive. In other words, each research effort adds identically and cumulatively to the overall level of knowledge on this issue. Synergy effects[1] are insignificant. What is important here is to ensure that countries do not free-ride and other countries' efforts. The role of the EU here is to encourage the development of research elsewhere through research assistance and technological transfers.
Another archetypical production function is the "weakest-link" scenario. Effective knowledge is limited by the level of effort of the smallest contributor. This is mostly the case for situations of technological transfers such as the control of epidemic diseases. Their eradication depends mostly on the effort of the least stringent country. The question here is to foster research and technological transfers in these countries through assistance.
The third situation is the "best-shot" scenario. The level of knowledge is determined by the greatest individual efforts. It is the case when research requires huge initial investments. The countries /research centres that have invested the most are more likely to make a breakthrough whereas all smaller contributions to research will be made redundant and will yield only marginal benefits. Gains in effectiveness then depend on the capacity to pool resources and to direct them towards the efficient S&T producer in this area.

2) Create value added with respect to existing partnership, multilateral initiatives, and coordinated bilateral cooperation

The following points summarize the usual warnings – but they should apply to the whole research landscape, and not just to cooperation among member states.

- Make sure we **do not duplicate** what exists already – or crowd out what could have been invested by others
- Continue the de-fragmentation process and reinforce successful cooperation – by **supporting existing networks** and helping them to expand - by coordinating better also with existing multilateral institutions
- Invest in areas which are **improperly or insufficiently addressed by national research systems,** such as researches conducted on a multisectoral – transdisciplinary basis, as opposed to thematic disciplinary research.
- Develop the analysis of the human dimension of sustainable development in relation to global challenges. Not enough work is done for example on **participatory approaches** or on community based management of natural resources for example.

1 There are positive synergy effects when the cost of producing knowledge A and knowledge B together is lower than producing it separately

- Invest in research areas which **are insufficiently developed by the private sector** (because they do not provide sufficient short to medium term profit perspectives) but are going to be crucial for our common future.

3) Close the gap between knowledge and policy

More policy oriented research is needed: it is pointed out that there are issues for which we have the technical know-how but for which there is an **implementation gap**. We are often able to develop effective technological responses but they are not adopted because they are ill-adapted to demand. Research has neglected to analyze the reasons why existing knowledge is not mobilized.

4) Invest in win-win cooperation strategies

Following the global public good logic, the EU should address research needs in countries where these problems are most acute and which may be a weak link in the strategy to mitigate their global impact.

One of them is to address properly the **knowledge gap in most developing countries**: the EU needs this research capacity as much as they need it because research on global challenges is rooted in local analysis and is most efficiently provided by the people having local expertise rather than expensive consultants. This requires to engage **into long-lasting cooperation and to reinforce public research capacity** in countries which have seen their research services dismantled by structural adjustment programs. It also implies that the EU reconsiders the brain drain problem. It is not helping the EU to attract the best scientists in EU and to keep them in Europe.

Mechanisms that should be reinforced or created to foster IC on global challenges

1) Improve existing mechanisms

- simplify procedures
- set clear financial targets in neglected areas
- provide equal treatment for native EU and external researcher
- improve symmetry in access to funding by research funding agencies
- develop web-based and network cooperation. The research community – public and private – develops the capacity to react in emergency and to deal with irreversible effects of these crises. Only genuine international cooperation based on team networks can help research and technology to produce workable results. The EU therefore needs to promote such networks, capable of pooling human resources rapidly and efficiently to respond to an emergency situation.
- de-fragment calls to allow multi-issue research programs. It was pointed out that the disciplinary/thematic structure of national funding could impede – or at least limit –

researches conducted on cross-cutting issues with a more systemic perspective: examples were given on adaptive water management, the multidimensional consequences of the development of biofuels, or the development of health systems.
- allow for more stakeholder participations – action-driven research
- encourage synergies between RTD and external policies programmes for a better efficiency with quantitative objectives.

2) New mechanisms or recommendations

- To facilitate the development of a research agenda and research programs taking into account different interests, including those of impoverished communities. This could be done by establishing an EU network of research and development, involving both **knowledge producers and knowledge users** and ensuring linkages to existing national initiatives and international institutions.
- To promote the development of a new discipline "**Global Public Economics and Management"** (GPEM) aiming at designing more effective and efficient international cooperation policies, instruments and institutions. The formulation of GPEM building blocks could be done by creating and drawing on a network of scholars and policymakers so as to lay the ground for future policy ownership, to foster a multi-disciplinary approach that cuts across various global issue-areas, to reach out to existing international economics networks. It could be an EC initiative led by DG research to benefit from Europe knowledge and experience with transnational public policy.
- Finally, it was suggested that new funds be made available to finance S&T on global challenges. It was also argued that one way to go global is to **be financed globally**. Although a number of solutions have been discussed in various international fora (tax on airplane tickets – in place in some countries; tax on the CO2 footprint of traded products; the well-known Tobin tax), we are far from finding a consensus on this issue. The EU could take a leading role by marshalling political will towards such solutions.

Setting the scene

Key global challenges and threats to the world

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This paper examines the interaction of socio-economic divisions, marginalisation and environmental constraints as drivers of international conflict in the context of the current western security paradigm. It then indicates possible areas for EU programmes on scientific and technological cooperation.

Causes of Conflict

While the issue of political violence since the 9/11 attacks is seen in most western countries as the main determinant of international conflict, there are much more substantial global drivers of insecurity likely to operate over a 20-30 year time-span.

Socio-economic divisions. The globalised and largely unrestricted free market economy of recent decades has resulted in impressive economic growth across much of the world, not just in the countries of the Atlantic community but most notably in South and East Asia where growth rates in some countries have been exceeding 7% per annum. There have been some irregularities in overall economic growth, most notably the downturn that commenced in Asia in the late 1990s, and there are currently expectations of more limited economic growth in the near future. Even so, the overall record has been one of widespread economic growth, especially in the past fifteen years.

At the same time, the current world economic system has been singularly unsuccessful in ensuring a fair distribution of the fruits of that growth. Instead, a remarkable division has evolved between around one fifth of the world's population that has done impressively well over the past forty years and the majority that has been largely excluded from the effects of economic success. The deep divisions developed in the decades after 1960. In that year, the richest 20% of the world's people had 70% of the income and the poorest 20% had 2.3%, but by 1991 the richest 20% had 85% of the income and the poorest 20% had 1.7%. (Ghosh, 1997)

The very large "elite" is not concentrated in any one country, even if the majority is in the Atlantic countries of North America and Western Europe, together with Japan and Australasia. There are also significant parts of the population of relatively poor countries that have experienced the fruits of economic success. Of the 1.2 billion people among this global elite perhaps a third are in China, India and countries such as Brazil, but the numbers frequently represent small minorities of the entire populations of these countries. In China and India, for example, what might be termed “middle class” communities may

number well over 100 million, but still be much less than a fifth of the whole population. Furthermore, a number of advanced industrial states have substantial minorities, often exceeding well over a tenth of the population, for whom the recent decades of economic growth have had little impact.

It is not that the poor are getting poorer. As Gallagher shows in this report, many millions of people have been taken out of extreme poverty, even if millions more remain impoverished. The problem is one of an increasing divide between a relatively small part of the world's population that has done exceptionally well, and a large majority that has fallen behind in relative terms.

The extent of the division is remarkable, quite apart from the "super-elite" (for the first time, the 2007 *Fortune 500* list of the richest Americans were all dollar billionaires). This is most evident from figures for the distribution of household wealth. According to the UN's World Institute for Development Economic Research, the richest 10% of the world's population has amassed 85% of household wealth and the poorest 50% have just 1% (Davies *et al*, 2006). This socio-economic divide has evolved over several decades, has become markedly more wide since the 1970s and there are no indications of any narrowing of the gap. Put bluntly, the globalised and largely free market economy has resulted in economic growth achieved with little in the way of socio-economic justice.

Education and Communications. At the same time, perhaps the most impressive progress in human development of the past forty years has been the improvement in education across the majority world. A far higher proportion of the marginalised majority of the world's people now receives at least four years of primary education, literacy rates are much higher and the improvements in education and literacy are at last being more commonly enjoyed by girls as well as boys, women as well as men. While there is much more to be done, this is an immensely impressive achievement resulting primarily from intense efforts made within less developed countries. There have also been major changes in communications, not least with radio and television. The "data poor" aspect of the digital revolution may still be with us, but even that is being redressed by the wider use of the web.

All of these changes are to be welcomed as some of the most significant aspects of human progress, but they also involve a marked increase in the awareness of marginalisation by the majority of the world's people. During the 1970s, western economic growth was said to embody a "revolution of rising expectations" as people looked towards the consumer benefits of expanding economies. Now, the more likely result of the failure of the global economy to ensure socio-economic justice is a potential "revolution of frustrated expectations".

One of the main results of these evolving imbalances has been a very substantial increase in migratory pressures, with the phenomenon of economically-motivated migration impacting most commonly on richer countries that are close to regions of relative poverty. Some of the most powerful examples have been migratory pressures from Eastern Europe, the Middle East and North Africa towards Western Europe, from Central

America towards North America and from South East Asia towards Australia, an issue explored in depth by George in this report and, as discussed later in this paper, one that will be greatly exacerbated by the impact of climate change.

Consequences of these pressures are increasing antagonisms within domestic populations towards such migrants, often fostered by political parties seeking increased electoral influence. There is, furthermore, a tendency to "securitise" migration, seeing it as a threat to national security that might require increased border security and repressive surveillance.

There is also a marked risk of internal social unrest as a consequence of rising inequalities. In China, for example, the impressive but hugely unbalanced economic growth of the coastal cities has been accompanied by many thousands of examples of social unrest including riots and other violent demonstrations, especially in the towns and cities of provincial and rural China were the majority of the population still live. India has seen remarkable economic growth in recent years but it has also seen, against all expectations, the renaissance of the Naxalite neo-Maoist rebellion, which now affects more than one third of all of the states of the country. Much of the support for the al-Qaida movement comes from marginalised young men across the Middle East, South West Asia and overseas diasporas who may be quite well educated and not in dire poverty yet who see themselves as thoroughly and persistently marginalised.

A powerful representation of the view from marginalised communities came at the start of the Zapatista rebellion in Mexico in 1994, when a rebel communiqué announced:

"We have nothing, absolutely nothing – not decent shelter, nor land, not work, nor health, nor food, nor education. We do not have the right to choose freely and democratically our officials. We have neither peace nor justice for ourselves and our children. But today we say enough!" (Stephenson, 1995)

The widening socioeconomic divide, combined with improving knowledge of marginalisation should be expected to lead to many more radical social movements. Indeed there may now be a tendency evolving for numerous anti-elite movements to develop in an unstructured if transnational manner, much as the anti-colonial movements developed against western European states in the 1940s and 1950. This alone could be a major determinant of insecurity, but yet another trend may be set to exacerbate that tendency, elevating it to the principle issue in global conflict.

Environmental Constraints. There is no indication that the trend towards socio-economic divisions is easing, and the divisions are likely to be exacerbated by the impact of environmental constraints. One form of constraint is the location of some of the world's key resources, notably oil and natural gas, in very restricted parts of the world, the most notable example being the concentration of close to two-thirds of the world's oil reserves in the countries around the Persian Gulf, but other global issues have come to be recognised as having even greater importance.

In the late twentieth century, the world-wide human community began to have an impact on the entire global ecosystem – the biosphere – for the first time in history. Before then there had been major local and regional effects stemming from such phenomena as atmospheric and water pollution, land dereliction or depletion of marine fisheries, but none had had a global impact. The first example of such an impact came in the early 1980s with the recognition that a small group of chemicals, the chlorfluorocabons (CFCs), were degrading the ozone layer in the upper atmosphere that protects living organisms on the earth's surface by filtering out excessive ultra-violet radiation from the sun. The potential destruction of the ozone layer was recognised as a matter of great urgency and in a remarkable example of international cooperation the 1987 Montreal Convention was agreed that resulted in the phasing out of the use of CFCs.

The complete removal of CFCs will take many years and their impact on the ozone layer is persistent over decades, but it is unlikely that the destruction of the ozone layer will get any worse and the layer should ultimately recover. This is something of a success story but was made easy by the limited range of chemicals that were responsible and, in particular, by the ease with which they could be replaced.

This does not apply to the much greater example of a global human impact, progressive climate change due primarily to the emission of carbon dioxide from the burning of fossil fuels. There is now a broad international consensus that climate change is by far the most important environmental problem for the 21st century and that urgent action is required to prevent catastrophic damage to the biosphere and, consequently, to the world community. This is made more urgent, and links in with socio-economic divisions, by a recognition that it is likely to have a profound effect on the regions of the world which have the greatest incidence of poverty and disempowerment.

Until about 15 years ago, most climate change research tended to show that the temperate regions would be those parts of the world most affected by climate change. Britain, for example, would get warmer and windier, with northern and western parts getting wetter and the south and east getting drier. Much of southern and eastern Europe would become markedly drier, leading to major problems of water resource deficiencies, especially in the countries of the Mediterranean littoral. Even so, if the main impact of climate change was in the northern and southern temperate latitudes, then at least it would affect countries that had the economic resources to adapt. There was a belief that the tropical and sub-tropical regions would be "buffered" by natural processes from the impact of human-induced climate change, just as they had been buffered and therefore largely unaffected by prehistoric examples of natural climate change.

By the mid-1990s, this relatively hopeful prognosis had largely changed and it became recognised that those regions would be greatly affected in three ways. One would be raising sea levels affecting many of the large coastal cities of the south and also the low-lying but very fertile river deltas such as the Ganges/Brahmaputra. A second would be a pronounced increase in the intensity of tropical storms, especially typhoons hitting densely-populated land masses and causing numerous casualties and catastrophic damage.

The third and most damaging aspect of climate change would be major changes in the distribution of rainfall, with many areas subject to long-term drought (Rind, 1995). Given that the tropical and sub-tropical land masses are home to most of the world's people and provide the agricultural systems that feed them, there is the potential for huge problems of food scarcity.

All of these issues of tropical and sub-tropical climate change will affect societies least able to cope with the consequences and will interact with the enduring problem of socio-economic marginalisation. Unless these trends are altered, especially the "drying-out" of tropical and sub-tropical land masses, it would be wise to expect an era of intense migratory pressures at a level far higher than those currently due to economic difference, coupled with a more intense evolution of radical and extreme social movements as many people on the educated margins respond to their predicament.

The Security Paradigm. The final issue is that the current western security paradigm is essentially short-term and concentrates primarily on maintaining the security of the countries of the North Atlantic and their international interests. It is state- and alliance-centred and does not extend to addressing the underlying issues of marginalisation and environmental constraints. It has been appropriately termed "liddism" – keeping the lid on security problems and seeking to maintain control within a status quo, rather than addressing the problems at root. (Rogers, 2002) While the recent proposals on responding to climate change are welcome, they are not remotely sufficient to reverse current trends. There has been some progress on the issue of debt relief but virtually none on trade reform or on development strategies designed to foster sustainable and gendered development.

What there has been is a marked evolution of western military forces away from the mass forces relevant to the Cold War confrontation. Instead there is a much greater emphasis on an ability to conduct operations world-wide, including a concentration on long-range airborne strike capabilities, amphibious forces and counter-insurgency tactics. The thinking behind this comes out clearly in the recent Noabar Foundation report from five former European and US defence chiefs, *Towards a Grand Strategy for an Uncertain World,* the introduction making this clear:

"In their long-term agenda the authors propose abandonment of the two-pillar concept of America and Europe cooperating, and they suggest aiming for the long-term vision of an alliance of democracies ranging from Finland to Alaska. To begin the process, they propose the establishment of a directorate consisting of the USA, the EU and NATO. Such a directorate should coordinate all cooperation in the common transatlantic sphere of interest" (Noaber, 2007)

The entire report is written from this perspective - "the common transatlantic sphere of interest" - and only a "super-NATO" can bring security for its members and order to the wider world. Moreover the North Atlantic is a fundamentally civilised community that is under threat from the forces of disorder – the barbarians at the gate. It is, furthermore, an

essentially benign community and this is at the core of the western security paradigm. What "we" are about is liberal democracy rooted in the free market, with this being the current apogee of world civilisation.

Perhaps the most significant example of the control paradigm has been the conduct of the "war on terror" since the 9/11 attacks. This has concentrated very much on a series of military operations in South West Asia and the Middle East, terminating rogue regimes in the pursuit of the al-Qaida movement, rather than seeing the original atrocities as examples of mass criminality that required a large-scale policing and co-ordinated international legal response.

It is not an approach that has been effective, with the Iraq War entering its sixth year and the Afghanistan War heading towards its eighth year. Since 9/11, well over 150,000 civilians have been killed, over 120,000 people have been detained without trial, some for more than six years, and there have been numerous examples of torture, prisoner abuse and rendition. The al-Qaida movement is stronger and more popular than before and there has been an increase in anti-Western opinion across much of the majority world, especially in the Middle East.

Consequences

Although it may be argued that the conduct of the war has been counter-productive to western security, the control paradigm remains largely unchallenged and there is a strong perception in western security circles of a threat from without, as exemplified in the Noabar Report. This was expressed vividly by Wolfgang Sachs shortly after the end of the Cold War in phraseology that remains relevant today:

"The North now glowers at the South behind fortress walls. It no longer talks of the South as a cluster of young nations with a bright future, but views it with suspicion as a breeding ground for crises.

At first, developed nations saw the South as a colonial area, then as developing nations. Now they are viewed as risk-prone zones suffering from epidemics, violence, desertification, over-population and corruption.

The North has unified its vision of these diverse nations by cramming them into a category called 'risk'. It has moved from the idea of hegemony for progress to hegemony for stability." (Litherland, 1993)

In his view the North has utilised the resources of the South for generations but has now come up against environmental limits to growth:

"Having enjoyed the fruits of development, that same small portion of the world is now trying to contain the explosion of demands on the global environment. To manage the planet has become a matter of security for the North." (Litherland, 19993)

Within this context there is the specific issue of resource constraint stemming from international trends in oil resource location and use. The countries around the Persian Gulf, especially Iran, Iraq, Kuwait, Saudi Arabia and the United Arab Emirates, collectively have over 60% of all the world's remaining proved reserves of high quality oil, with much of the rest in Russia, Kazakhstan and Venezuela, together with sub-Saharan Africa. At the same time, Western Europe, Japan and India are all heavily dependent on imported oil.

Even more significant has been the increasing oil import dependency of the United States and China. The US now imports about 60% of all the oil it needs, with this set to rise still further as its domestic reserves are depleted (US reserves are currently about a quarter of those of Iraq). China was self-sufficient in oil until 1993 but will need to import half of all its massively increasing requirements within two years. As a result, the United States ensures that there are massive military forces organised in US Central Command (CENTCOM) to maintain control of the Gulf region, and China works diligently to develop close economic ties with key oil producers, especially Iran. Furthermore, both countries seek to increase their influence in oil-rich sub-Saharan Africa, with the United States establishing a new unified military command, AFRICOM.

In summary, the challenges to global security in the coming decades can therefore be summarised as:

- Increased human suffering and social disruption due to the combination of the impact of climate change and the widening socio-economic divide.
- Very substantial increases in migratory pressure leading to attempts by richer communities to maintain their levels of wealth by rigorously controlling migration.
- The further development of radical and extreme social movements in reaction to these trends.
- An increased risk of conflict over physical resources.

As pointed out by the economic geographer Edwin Brooks nearly 35 years ago, the risk is of:

"A crowded glowering planet of massive inequalities of wealth buttressed by stark force yet endlessly threatened by desperate people in the global ghettoes." (Brooks, 1974)

Responses

Avoiding such a dysfunctional global condition will require a greatly heightened commitment to development, not least in terms of trade reform, debt cancellation and direct international assistance targeted at sustainable and gendered development. It will require, furthermore, a remarkable commitment to preventing climate change and ameliorating those effects that cannot now be avoided, especially in poorer countries.

In terms of scientific and technical cooperation, the priority areas have to be energy conservation and the development of renewable energy resources, moving rapidly away from the current dependency on fossil fuels. Specific areas for research and development include intensive work on solar energy, especially third-generation photovoltaic systems, robust wind and wave power systems and ground and air-source heat pumps. There is a particular need for intensive work on energy conservation, improving the efficiency of almost all the current energy use systems, and also on advance energy storage systems including fuel cells and kinetic storage. Such areas of work have to be applied both to the industrialised states, which still retain the greatest responsibility for climate change, and also to aiding poorer states. It is essential to ensure that they are able to improve the standards of living of their own people in a manner that does not have the effects on the global climate that have been typical of the industrialised states.

While all these developments will aid industrialised states in reducing carbon emissions, they are at least as important in enabling industrialising states such as India, China and Brazil to transform their economics with minimal impact. Furthermore, given that many of the systems could be developed for localised use, their impact in improving the circumstances of poor communities, whether urban or rural, could be considerable. To help ensure this, there is a critical need for scientific and technological research and development in southern states to be rooted in a culture that, as Abrol argues elsewhere in this report, is rooted in the public good.

There also have to be substantial and urgent programmes designed to enable poorer countries to avoid the effects of climate change that are already inevitable. These have to include urgent programmes to develop food production systems able to cope with climate change, and programmes to ensure greater infrastructure resilience in the face of more violent weather, especially in coastal regions. In relation to the former, there have been welcome increases in investment in versatile crop varieties that can maintain productivity in adverse water environments, but even these increases are inadequate in the face of the impacts of climate change that are likely even if the control of carbon emissions comes much faster than is currently envisaged.

These are examples of areas of concentration that require very substantial resources, certainly commensurate with current military expenditure, and require the kind of trans-national cooperation for which the European Union has considerable potential. The timescale for rapid change is through to 2015. If there can be a reorientation to a "sustainable security" paradigm, then prospects for a more stable and peaceful world could be good. (Abbott *et al*. 2006) If not, then Brook's "crowded glowering planet" is the likely outcome.

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Examining relationships between European Union policies and migratory pressures

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As the relevant agencies of the United Nations never fail to remind us, we live in an age of vast population movements. Millions of people are making the one-way transition from countryside to city, with the result that more than half the world now lives in an urban environment. Not infrequently, in countries like China, entire villages may be obliterated by mammoth "development" schemes and the inhabitants are relocated, usually under worse conditions. Millions more have been forcibly displaced by various types of armed violence within their own countries and are known as "internal refugees". Finally comes the group that has already accomplished the rural-urban transition, sometimes thanks to the previous generation, and which, for reasons which remain to be fully explained, are desperate to migrate to foreign countries that they see as promised lands. These candidates for departure almost always seek to enter the wealthy OECD countries. Mexicans and Central Americans head for the United States; North Africans and Sub-Saharan Africans, as well as Eastern Europeans and Central Asians, attempt to cross the borders of the European Union.

Defence and illustration of the hypothesis

The brief analysis and research proposal that follow will be confined to the EU but the observations made could as well apply to North America or Australia. Within Europe, responses to increasing migratory pressures have varied from country to country but initially at least, they all treat migration as a security problem, to be dealt with primarily by the police, the coast guard, the prison or retention-centre system and, in extreme cases, the army or the navy.

The common characteristic of their various security approaches is, however, that they have not worked. This, at least, is the case if the definition of measures that "work" are those that reduce or stop the phenomenon of migration, or limit it to well-educated individuals the receiving country is happy to accept. Present approaches have clearly not stemmed, much less prevented the flows of people entering Europe in a variety of more or less clandestine circumstances. To the contrary, they are arriving in greater and greater numbers, often under appalling conditions. More and more deaths in transit are reported yet still they make the attempt. Many more "hidden" immigrants are simply people who arrived on a tourist visa and never left.

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Let us ask an apparently simple question: Is out-migration from "South" to "North" on such a scale a "normal" phenomenon? Young people especially want to travel, but few, given the choice, would choose permanently to leave their countries, familiar landscapes, food, childhoods, families, friends, memories, languages....without serious motives. They would especially not risk their lives and gamble their futures in order to cross the borders or reach the shores of Europe, only to be confronted—in case of success—with the life of a marginal "sans papiers", a paperless person: menial, ill-paid jobs, precarious living conditions, crowded sub-standard housing, no civil rights, possible imprisonment and deportation, racism, xenophobia....

Should we not therefore accept at least the *hypothesis* that mass migration is not "normal"; that migration candidates would, more often than not, avoid it if they had other options; that the "push factors" causing people to leave their home countries in such numbers require much closer examination than they have so far received? Among such factors should we not also accept the hypothesis that, in the case of Europe [as would be the case for other OECD countries], its own policies may have more than a little to do with out-migration?

Even a quick survey of the literature on migration shows a surprising absence of any such hypothesis. Within my time constraints and in the interests of efficiency, I did not attempt an exhaustive search; I did, however look at the work done by the United Nations University World Institute for Development Economics Research [UNU-WIDER] which has organised various conferences and produced many discussion papers and publications on the issue of migration.[2] Other sources examined include the publications of the Centre on Migration, Policy and Society [COMPAS] at Oxford University[3] and the twenty years-worth of articles published by the REMI—*Revue Européenne des Migrations Internationales*.[4]

None seem even to have considered the idea that European policies might create or reinforce pressures in North African and Sub-Saharan societies to migrate. This also seems true for the impact of United States policies on its southern neighbours, judging by twenty years worth of output by the Center for Immigration Studies in Washington which describes itself as the "only think tank devoted exclusively to research and policy and ....impacts on the United States [of migration]".[5]

2 UNU-WIDER, "Seminar on International Migration and Development: Patterns, Problems and Policy, United Nations, New York, 12 September 2006; or UNU-Wider seminar in 2001 on "International Migration and Poverty; also Timothy J. Hatton and Jeffrey G. Williamson, "What Fundamentals Drive World Migration?", UNU-WIDER Discussion Paper no.2003/23. The ongoing WIDER project on Refugees, International Migration and Poverty is co-directed by George Borjas of Harvard and Jeff Crisp of the UNHCR.
3 http://www.compas.ox.ac.uk/publications. There are ten subheadings of various types of publications.
4 http://remi.revues.org/entrees.html?type=motcle Keyword search.
5 www.cis.org Founded in 1985, the Center defines itself as non-partisan and non-profit; "pro-immigrant, low immigration"; that is, it aims for fewer immigrants and a better welcome for those who do come. The "Right Wing Watch" of People for the American Way considers the CIS as a rightist organisation. It is thus all the more surprising that CIS has shown no apparent interest in US policy contributions to "push factors".

On one hand we are confronted with the evidence of increasingly desperate people willing to undertake harrowing, dangerous, long-distance journeys—journeys often requiring the life-savings of entire families and sometimes ending in death. On the other hand, virtually all the literature stresses that migration to Europe is caused by "poverty" or "socio-economic deterioration of the situation" at home; or "the growing gap" between North and South. These are the handy, catch-all explanations.

More sophisticated analyses may point also to the lack of security in countries torn by civil strife; improved communications and information systems that give an unrealistic picture of life in the rich countries; social solidarity networks established by and with previous immigrants; the fairly recent emergence of an entire industry of commercial, usually criminal, people-trafficking enterprises devoted to recruiting and smuggling migrants across international borders and so on. Those analyses that invoke "poverty", "deterioration" and "gaps" do not seem to consider it their business to ask why these should exist on such a vast scale.

Two possible conclusions may be drawn from these remarks. Either [1] European economic/trade policies are universally beneficial to the southern "sending" countries and therefore contribute nothing to migratory pressures or [2] the supposedly benign nature of European policies *vis à vis* sending countries is the unspoken, quasi-universal assumption of governments, research institutes and academics. Thus the question of possible negative impacts does not even arise. If, however, EU policies are universally beneficial, as in alternative conclusion [1], we ought to be able to find proof to back up that claim—proof that would also be "falsifiable" in Karl Popper's sense. If, on the other hand, this is an unspoken but unexamined assumption as in alternative conclusion [2], links between European policies and out-migration pressures might be shown to exist but have never been seriously looked for. In either case, but particularly in the second, it would seem that we face a research gap of quite staggering proportions.

Obviously one does not want to fall into the trap of the "mono-causal explanation" for any phenomenon, but in the case of such a major policy preoccupation for European governments and citizens as migration, surely it is worth examining seriously the impact of EU policies on population movements. Surely experience so far shows that the security-police approach is at best partial; at worst a failure and that root causes have not necessarily been identified, much less taken into consideration and dealt with.

European decision-makers of all political persuasions recognise that migratory flows from South to North constitute a problem area. These decision-makers should welcome more precise knowledge and assessment of the impact of European policies, not merely on Southern governments, but also on the lives of communities and the vast majority of Southern populations that constitute the human pool from which migration springs.

The overarching goal of European policy towards the sending countries should be that of the Hippocratic oath: "First, do no harm". A courageous research programme has the duty to assess such harm, if it exists, and if so, to devise means to eliminate it and replace it with positive approaches. Nothing could improve the stature of the European Union

with its Southern partners more than this. It is true that Europe, like any other political entity, has many constituencies to satisfy as well as many economic and political interests and cannot be expected to abandon them. Some of these constituencies and interests may, however, be quite limited in importance and of short-term value only. They could and should be replaced by the approach once known as "enlightened self-interest" which deserves a revival.

What might be the elements of such a research programme? Here follows a non-limitative "catalogue" approach. North-South research teams would be needed to deal with them. I wish to state at the outset that my own biases will be evident in some of the suggestions put forward for research work. I do not believe in "objectivity" in the social sciences and I have done too much work over past decades concerning the impact of certain Northern policies on Southern societies to put forward proposals for the EU with a "neutral" attitude.

This being clear, the key areas of European policies to examine concern debt and structural adjustment, trade [particularly with regard to food and agricultural goods] as well as tariff structures; subsidies, commodity prices; fisheries, the impact of European transnational corporations; Economic Partnership Agreements [EPAs].

On the side of the migrant-sending country governments, one should also consider incentives *not* to cooperate with the EU and even to encourage migration either overtly or tacitly. Southern governments know very well that remittances sent home by migrants constitute a substantial component of their revenues and that they relieve the poverty of a great many of their citizens and villages. For several countries, emigrants already represent their most valuable export. Governments know too that the "export of people" mitigates their own severe unemployment problems. For these governments, it can only be an advantage to have in particular fewer discontented, unoccupied young men around to cause trouble. These governments are only too happy for these people to be outside, not at home.

In addition to these present North-South aspects, particularly those linking the EU and North/Sub-Saharan Africa, one should also study and plan for the longer term impacts of climate change. We already know that drought-prone areas are set to become even drier and water-stressed populations will necessarily increase. In the same way, already humid areas are likely to experience more rainfall and floods. The rise of coastal waters will also create untold numbers of climate refugees seeking relief at any cost and severe weather events are slated to increase, with all their attendant dislocations.

European policies with possible or likely immigration-inducing impacts

1. DEBT

Despite modest reductions, outflows from South to North remain a heavy burden on Southern countries and hamper their development. Research must quantify this burden

and assess the current value—including monetary and non-monetary value—of reimbursement to individual EU countries and to the EU as a whole. What is the level of funds "sterilised" by debt repayments and therefore unavailable for development? What are the real impacts of debt-induced structural adjustment packages, particularly the privatisation of public services and export-orientation, particularly of agriculture? The debt "crisis" is in fact a chronic illness and ideally the EU should, with the help of research, devise a quick, clean, democratic, non-bureaucratic, corruption-free, "once-for-all" plan that can put an end to a problem that has festered for easily a quarter century.
Debt was accumulated for a variety of reasons; the borrowed money came from both public and private sources but in the case of Sub-Saharan Africa, they were overwhelmingly public. Loans to oppressive regimes have been estimated at about $500 billion worldwide [including $22 billion to apartheid South Africa]. One would need to examine the "odious debt" aspects [jurisprudence since the 1920s distinguishes legitimate from "odious" debt, the latter going to dictators either with no benefit to the population or serving to oppress that population further]; but the recommendation here would be for cancellation of all types of debt.[6]

Loans on the books to Low Income Countries [LICs], amounted in 2004-2005 to about $523 billion worldwide. Africa's external debt, including that of North Africa, had by 2004 reached $300 billion with $227 billion for Sub-Saharan Africa alone. These sums are quite small by international standards but insuperable for Africa: in 2004, Sub-Saharan Africa was paying back $28.000 a *minute* [$15 billion a year] in debt service, according to World Bank-OECD figures. All the LICs taken together were then paying back $100 million a day/ nearly $70.000 a minute

As of July 2005 at the time of the Gleneagles G-8 Summit, 28 countries had been assured of $56 billion in debt relief and 18 very poor countries, including 14 in Africa, were promised total cancellation. In such severely indebted countries, the Millennium Development Goals [MDGs] will take 100 years to achieve on current trend lines. Civil society campaigns like that of Jubilee 2000 have led to pressure on the creditor governments, yet relief promised has always been very slow to translate into reality because the target countries are obliged to undertake further periods of structural adjustment before cancellations take effect. At least 65 countries have been estimated to need complete debt cancellation in order to have even a chance of meeting the MDG targets. This would cost the creditors about $80 billion/year. G-8 and other meetings tend to make spectacular announcements which turn out on closer examination to be misleading or remain unimplemented.[7]

Intimately linked to the debt crisis is the enormous burden that capital flight from Africa has imposed on this poorest continent. Recent work by Léonce Ndikumana and James K. Boyce of the University of Massachusetts reaches the conclusion that Africa's wealthy have, during the period from 1970 to 2004, exported a total of $420 billion, nearly double

6 Patricia Adams, Odious Debts, Probe International, Earthscan, Toronto, 1991
7 Susan George, A Fate Worse than Debt, Penguin, London 1987; Susan George, The Debt Boomerang, Pluto Press, London, 1992; Patricia Adams, Odious Debt, PUBLISHER DATE; more recent figures regularly published by the Comité pour l'Annulation de la Dette du Tiers-Monde-CADTM, www.cadtm.org

the total debt burden of Sub-Saharan Africa in 2004, which in 2004 was $227 billion. Most of this money was not acquired legally. With the interest this capital could have accumulated over the 35 year period, the authors estimate the total loss to Africa at $607 billion. How complicit were European banks—and how lax might European governments have been--in allowing or encouraging this chronic drain?[8]

2. STRUCTURAL ADJUSTMENT

Beyond assessing the amounts presently owed, research should summarise the vast literature on the impact of structural adjustment policies accompanying debt, put in place by the World Bank and the International Monetary Fund, working in close cooperation with the United States Treasury. The elements of structural adjustment [also known as "Washington Consensus"] policies have been frequently and exhaustively studied; dozens if not hundreds of case studies exist on the impacts of high interest rates, export orientation and market liberalisation, privatisation; 'cost-recovery' [fee-paying] including fees for schools and health care--particularly detrimental to women and girls—and so on. These policies have caused increased hunger and deprivation, smaller numbers of children in school, chronic unemployment and hardship; millions have had to fall back on the informal sector.[9] Although local populations benefitted little or not at all from the borrowed money, most of which went to the middle and upper consuming classes, "white elephant" projects, arms purchases or private accounts abroad; these populations have been obliged to pay it back with their sacrifices.

We already know that debt cancellation is affordable. Research would need to examine the amounts owed to specific EU countries and the total amount over which Europe could have an influence [including sums still owed to the World Bank and the International Monetary Fund]. The sources for such work exist: the World Bank, the OECD and the London Club and the Paris Club are the main ones—although this researcher has found the Paris Club to be singularly uncooperative, indeed contemptuous of external requests for information. A mandate from the EU would undoubtedly be required to gain access to its data.

As for the Bank and the Fund, the IMF could continue to sell its gold without upsetting markets—indeed it would help to calm the sky-rocketing prices for the precious metal. As for the Bank, even if it were to write off all the debt owed to it by all the LDCs, it would simply return to its capital levels of 1997, when it was flourishing. The Bank has 400 percent more capital than it needs to keep the triple AAA rating for its bonds [all three of the best-known rating agencies rated its bonds AAA in 1997]. In addition, for the past 15 years, the Bank has made over a billion dollars a year in profits. European voting shares in the Fund/Bank amount to 16 percent for Germany, France and Britain alone, plus another 14 percent if one counts the groups presided by Belgium, Netherland and

8 Léonce Ndikumana and James K. Boyce, Tax Justice Focus, the quarterly journal of the Tax Justice Network, First quarter 2008, Volume 4 no.1,

9 In a memorable presentation, A.T. Moussa Tchangiri, director of the magazine Alternative in Niger, at the World Social Forum in Bamako [January 2006] described in fine detail how forced privatization policies [of transport, cereal stock-holding, veterinary services, etc.] had directly contributed to widespread famine in that country.

Italy. Surely 30 percent of the voting stock gives the EU enough influence in these International Financial Institutions to push for complete cancellation for North/Southern African debtors, based on solid research of the improvements that could be expected in these countries once freed from debt bondage.

Many argue that debt cancellation would simply lead to renewed indebtedness. One can, however, show—although research on these aspects is still thin—that when debt cancellation does occur, the money is on the whole well-used, for schools, clinics, immunisation, access to water… [data exist from Tanzania, Uganda, Benin, Mozambique…]. The EU, if it were to require that African governments associate their own people in the choice of priorities for spending the money freed up by cancellation, could insure that savings on debt repayments were used wisely everywhere.

Indeed, in exchange for complete cancellation, the creditor countries of Europe should have the right to demand that the recipient governments be accountable **to their own people** for spending the savings. Some variant of the participatory budgeting process used in many Brazilian cities could be used; one could also call for the election of a council composed of people elected on both a geographical and a sectoral basis [i.e. farmers, workers, entrepreneurs, women, civil servants...] to sit alongside the government and determine the spending priorities.

Some argue that it is not possible to impose "conditionality" on these sovereign governments, but this argument is spurious given that IMF-Bank conditionality has been imposed for decades. Democratic conditionality could simultaneously contribute to solving many governance issues in recipient countries. Where such formulas have been tried [Brazil, Tanzania...] waste and mismanagement of funds is reduced to virtually zero. A small UN Agency—or a European agency--could dispense the sums concerned to the central bank of each debtor country; the government assisted by the Council of its own citizens would determine how to spend it. If the UN solution is chosen, the one that dispenses the international "airline ticket tax" proposed by the then president of France Jacques Chirac and accepted so far by about 15 countries could do such a job; this agency is called UNITAID.

Debt cancellation ought normally to create huge numbers of jobs in the LDCs as well as allowing for much higher spending on health, education and other necessities. It would contribute to job creation in Europe as well, as former debtor countries began to be able to spend on capital goods, rather than on economically sterile interest payments.

3. COMMODITY PRICES AND TRADE

One of the most perverse impacts of debt is the export syndrome. All the indebted countries must earn hard currency to pay the interest owed and must therefore export. Particularly in Africa, indebted countries tend to export the same narrow range of primary products with the result that they produce more than markets can absorb and thus push down prices for everyone. Commodity prices have been declining since the 1970s. Lower prices paradoxically encourage overproduction because countries strive to keep

their income stable by exporting even more. Subsidies of northern countries, i.e. US subsidies to its cotton producers make matters worse and appeals to the World Trade Organisation do little good.
The share of commodities [oil excluded] in world trade has declined from one-third to one-quarter since the mid-1990s. Because of mass privatisation under structural adjustment policies, governments no longer have the tools to manage carryover stocks or control quantities produced and traded. According to UNCTAD, fifty low income countries are dependent on 2-3 commodities; 39 are dependent on just one. The terms of trade are set massively against raw material producers, with the result that they must export one-third more today than in 1975-85 to buy the same quantity of manufactured goods.

Although China's purchases have recently improved the prices of primary products somewhat, particularly for metals [which are never produced by smallholders but by large, usually foreign mining enterprises] the declines for cash crops have been consistent, e.g. an average 5.1 percent/ year for coffee; 6.9 percent for cocoa; 3.4 percent for cotton, since 1977. A Ugandan coffee farmer receives 14 cents a kilo for beans; the coffee in a UK supermarket eventually costs the consumer $26.40/kilo. [Figures from 2005]. European tariffs are low to non-existent for raw materials but high when goods are processed in the producer countries into more elaborate goods. Poor countries cannot compete in processing their own commodities because they face these high barriers. The European "Everything but Arms" policy has, however, been a positive step which could inspire further ones.

4. EUROPEAN TRADE POLICIES AND EXPORTS TO AFRICA

Subsidies in the North can contribute to ruining small farmers; see for example the impact of the above-mentioned US cotton subsidies on African producers. EU agricultural production is subsidised to the extent or about a billion euros a day: what proportion of those subsidies relate to products exported to African markets at prices below true costs of production? We need to know much more about the impact of European trade on small farmers and nascent industries in Africa, particularly the dumping of subsidised products. Some studies, particularly on dairy products, tomatoes and chicken, indicate that exports from Europe at unbeatably low prices have decimated local producers and processing industries [e.g. tomato paste production in Ghana]. There is probably more literature concerning NAFTA's impact on Mexican farmers than on EU impact on their African counterparts. [NAFTA has ruined at least 350.000 poor Mexican farmers in the poorest States as cheap, industrially produced US corn has flooded Mexican markets].
European Union officials will be aware of persistent Northern NGO criticism of the EU's present trade policies, whether in the WTO or in the various bilateral/multilateral agreements and EPAs [Economic Partnership Agreements] all of which contain detailed investment, raw-material access and government procurement provisions. The overwhelming bias towards the interests of European transnational corporations and the latter's influence over EU trade policy seems in little doubt. EPAs have been challenged by a few African countries [Senegal, South Africa] but most are acquiescing.

The very least the Commission could do would be to monitor the actual behaviour and impact of European transnational corporations, particularly raw-material extractors, in the migrant-sending countries. On the occasion of the EU-Latin American Summit held in Vienna in May 2006, the *Enlazando Alternativo* [alternative summit] commissioned studies by Latin American NGOs and researchers on the impact of European TNCs in Central and Latin America. Their eye-witness reports yielded a wealth of information and, it must be said, highly negative results for local populations, whether the companies concerned were engaged in mining, utilities, agricultural, paper or financial industries.][10]

5. FISHERIES

The fish catch along the western coast of Africa has plummeted and small fisherman can no longer make a living. Many say that the depletion of stocks is due to overfishing by European industrial trawlers. Small fishermen are said to be selling their boats to the people-smuggling rings that use them to try to take migrants to the Canaries. The situation may be similar for countries bordering the Mediterranean. Aside from anecdotes, we know very little about this phenomenon.

Addendum: Policies for which the EU is not directly responsible but which further impoverish migrant-sending countries.

1) **FREE TRADE**: Initially, the World Bank announced that developing countries would see massive benefits [over $300 billion/year] from genuinely free trade. Under pressure from economists elsewhere, the Bank was obliged in successive stages to scale back its estimates to a mere $16 billion, half of which was expected to go to Brazil and Argentina. The most that the poor countries are likely to see from more free trade is a 1 percent increase in GDP over the next 10 years.[11]
   The WTO has claimed that the stalled "Doha Development Round" would provide real gains for the South. However, the North, including the EU, has so far proposed granting access for only 97 percent of each southern country's goods. This may sound generous, but due to the reliance of so many Southern countries on a very limited number of products, the North can easily place what each country can produce economically in the category of the 3 percent remaining.

2) **WTO BANANA DECISION**: It may already be soon enough to assess the impact on local producers of the WTO ruling on the EU-ACP banana dispute. The preferential regime by which Europe guaranteed to purchase a set quantity of bananas from ACP countries was ruled WTO-illegal: Europe does not have the right to give any privileges to ACP countries and must accept, for example, the bananas produced on plantations by US transnational corporations like Chiquita Brands, in Ecuador or Central America. What has been the effect of this decision on poor ACP farmers? Has it increased their tendency to attempt migration?

10 http://peoplesdialogue.org/en/node/39

11 Kevin Gallagher of Tufts University, who also attended the EU meeting that gave rise to the present series of papers, including mine, has written decisively on this issue.

3) **MULTI-FIBRE AGREEMENT**: The end of the Multi-Fibre agreement gave China a huge advantage in textiles. Chinese exports have had a large impact in Europe itself, but in the South, the effect has been devastating. Textile industries in places like Bangladesh, Cambodia or Central America are unlikely to recover. In Morocco, the industry has already shed hundreds of thousands of jobs. These unemployed workers are going back to kif [drug] production or attempting to emigrate. Can the EU do anything to mitigate these impacts? Clearly in this case, they cannot be ascribed to Europe's own policies, but should they influence the EU's attitude within the WTO or in other international-system and/or trade regimes?

4) **FINANCIAL CRISES:** Even before the present market turbulence and incipient recession stemming from—but not confined to—the subprime crisis, financial meltdowns have taken a heavy toll. The International Labour Organisation has estimated that over 90 "serious financial crises" occurred between the beginning of the 1990s and 2002, with great loss of economic security, jobs, livelihoods and savings. The ILO definition of "serious" is that the value of the currency dropped by at least 25 percent in a single month and that this drop was at least 10 percent greater than the fall of the previous month. In other words, these are crises in which the value of peoples' bank accounts, insurance, social security, pensions, and so on fell by at least 35 percent within the space of two months.

5) **CLIMATE CHANGE:** Surely the impact of rapid climate change is no longer in doubt and needs no more research *per se*. The IPCC has established that dry/humid areas will become more drought/flood prone, that extremes of temperatures and secondary impacts will strike the vulnerable in the South with greater force than in the temperate zones of the North. We have already witnessed catastrophic floods in Sub-Saharan Africa and know that stresses of all kinds will multiply. Here is a perfect opportunity for European S&T to propose clean and abundant energy systems [particularly solar] for the South, in an all-out development effort to change not just the South but also Europe's own energy scenario. For the moment, palliative and relief programmes will be more necessary than ever.

Conclusion

During and after the decolonisation process, formerly colonised and/or dependent countries produced many brilliant and charismatic leaders [present at Bandung and beyond….]. These countries formed political groups like the Non-aligned Movement or the G-77 [which later numbered well over 100 countries]. From the 1970s in particular, they called for a New International Economic Order; various UN documents like the 1981 "Brandt Report" seconded many of their demands. It looked for a time as if there might finally be a fairer distribution of wealth in the world and greater opportunity for emerging nations. The North was obliged at least to pay lip-service to the demands emerging from a newly confident South.

In 1974 at the FAO Rome World Food Conference, Henry Kissinger [fresh from engineering the fascist coup in Chile] intoned that "Within a decade, no child will go to bed hungry, no family will fear for its next day's bread…" Other conferences followed and the South thought, with some justification, that it was making progress. Gradually, however, the North, led by the United States, brought the situation back under northern control. Other dictatorships besides that of Pinochet were introduced and supported by the North and former colonisers often underpinned undemocratic and repressive regimes in Sub-Saharan Africa. In Jamaica in 1981, the newly elected Ronald Reagan put a stop to the process of New Economic Order and greater autonomy once and for all.

The European Union as a comparatively new political entity has the opportunity to break with this past and show that it can not only cooperate but act as an advocate for permanent, equal partnerships in the South. Every ruined farmer, every unemployed youth, every fisherman without a livelihood is a candidate for migration. Europe can stop cutting off avenues to prosperity and development with its policies and make migration less necessary.

Naturally it would have to disappoint some more or less powerful European lobbies in the short term, but the benefits for Europeans as well as for the people of the South would be enormous. A fortress-Europe policy will not work and, under present circumstances at least, an "open borders" policy is politically unacceptable. The only other options are to reinforce the unsuccessful police-security-expulsion response or to study present European practices and decide to eliminate abuses—using research results to buttress the case. Otherwise, no one—particularly no European official should profess surprise as they witness the steady flow of incoming migrants.

The major challenges facing the world: analysis of the role of international research and S&T policies in addressing development issues

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Introduction

The international science and technology (S&T) cooperation programmes of the European Commission (EC) have addressed development issues on a project-by-project basis for over twenty five years. The EC responded to the recommendations of the 1979 UN Conference on Science and Technology for Development by setting up a programme for Science and Technology for Development (STD) in 1983. The EC's S&T relations with the developing countries found expression in the Framework Programmes (FPs), mainly through "S&T for Development" projects. Starting in 1983 under FP1 and continuing under the INCO programmes of FP4 and FP5, projects connected with S&T for Development have been a constituent part of the EC's research framework programmes over the last twenty five years. Throughout this period international S&T cooperation regarding developing countries also focused on mobilising the S&T capacity of Europe and partner countries to find solutions to basic needs such as health, natural resource management, environmental protection and food security. Initially the projects approached development issues by targeting promotion of new technologies. However, experience showed over time that such project approaches were insufficient to produce a broad-based societal impact, and so these approaches also changed over time. The EC came to place emphasis on more systemic approaches and focused on problems of regional importance in partner countries. In recent times, research priorities for international S&T cooperation have been identified through bi-regional dialogue or through reference to EU commitments at international negotiations.

Apart from these changes in emphasis, it has also become gradually clear that the partner countries' ability to harness research results is of considerable importance for developing process or product improvements. This is the experience of international S&T cooperation even when S&T cooperation projects have appropriately targeted problems of high priority for the partner countries. The impact remains weak due to weak or inappropriate public policies influencing the spheres of education and innovation. Take the case of Africa, which was a key target of international S&T cooperation in the field of agriculture during the Nineties. According to the official estimates of the Consultative Group on International Agricultural Research (CGIAR) in 1999, 40% of the more than US $3 billion invested during the previous 10 years in agricultural research through its research centres went to Africa. The results in Africa were poor, a consequence of underdeveloped linkages with national research systems and policy.

Furthermore, as a serious question mark has arisen worldwide concerning agricultural research into the sustainability of green or genetic revolution pathways due to increased inequities and environmental vulnerabilities, the scientists and policymakers involved on all sides must shoulder their responsibility and think of ways of avoiding similar collective failure in the future. Clearly, those involved did not attempt to specify who should obtain what from technology and science, and were not able to think things through and foresee the ways in which the priorities and organisation of science would actually have significant consequences for who obtains what, when, and how. It is not difficult to see that in Africa's case all of this happened in agriculture in the Nineties because the dominant actors' interests and the conditions shaping the policies on knowledge-base sharing facilitated the chosen pathways.

Of course, some may claim that the abovementioned failure of national innovation systems would not be an important issue in the case of international S&T cooperation with the BRICS group of countries, namely Brazil, Russia, India, China and South Africa which have — relatively speaking — a larger scientific and technological absorption capacity than Africa possesses. However, we would like to argue that this failure could also occur in connection with the BRICS group countries. Why? Because the problem is not merely one of the size of national innovation systems, but of the way the approaches to generating science, technology and innovation changed in these countries during the Nineties. Today the BRICS group of countries entails a different scenario in terms of the interests of the actors involved and the conditions for developing a shared knowledge base to produce solutions to basic needs. For the reasons discussed below in detail, it is suggested that even as equal partners in international S&T cooperation programmes they would not have the required impact on the problems of development in these countries.

The argument is that perusal of the pathways of sustainable development is significantly prevented in these countries today by the neo-liberal orientation adopted in implementing public policies for science, technology and innovation. The role of international research and S&T policies needs to be addressed in direct relation to the goals themselves. The paradigm of a "competitive" world which makes others poorer cannot be a legitimate basis for international research and S&T policies. In our view, if policymakers can begin to view the development issues of the developing world, including the BRICS group countries, as offering a major opportunity for the world as a whole to solve global problems, the world of international S&T cooperation would make a better contribution. By solving the well known problems concerning these countries' development, the world would be able to tackle global problems far more successfully. In fact, the global problems of security, climate change, poverty, hunger, disease, etc. cannot be solved independently. Their successful resolution hinges on pursuing sustainable development pathways in these countries. In fact, it is our understanding that the world as a whole should shun the practice of neo-liberal public policies in the sphere of science, technology and innovation. Solutions to global problems would be then forthcoming even faster[1].

1 As the countries of Europe themselves withdrew, somewhat, from directly supporting industrial development and placed greater emphasis on pre-competitiveness and generic technologies, the value of publicly funded R&D and international S&T cooperation is itself now judged differently. The issue of EU

Characterisation and analysis of science, technology and innovation policies in BRICS

During the Nineties, changes in the S&T landscape (policy cultures, institutions, infrastructures, regulations, and knowledge-production processes) were made in the BRICS group countries and increasingly implemented under the influence of the reform agenda of liberalisation, privatisation, deregulation and neo-liberal globalisation. There exists much evidence attesting to the negative impact the reform agenda of liberalisation, privatisation and neo-liberal globalisation is having on the overall health of the national innovation systems in the BRICS group countries. There is ample evidence of such negative impacts in those countries in the shape of the poor results achieved in formation of technological absorptive capacity and the provision of appropriate livelihood solutions for the poor. This is the case even when some of those countries have been able to achieve consistently higher economic growth rates than before. There is also evidence in the form of a counterfactual situation emerging to some extent from China's growth story.

Analysis of the growth performance of the BRICS group countries indicates that China's performance is by far the most dynamic of all[2]. This level of performance was made possible only in China's case because it successfully delayed the processes relating to external liberalisation of finance, trade and investment. However, it needs to be realised that even then China's high-tech exports are highly import-intensive and very much depend on the industrialised world's multinational corporations for capital goods, critical components and technology acquisition. While more advanced technologies are evident, the greater share of these has come from importing technology from abroad. It is widely felt that China's assimilation of this imported technology has been disappointing, and many in the research community believe that dependence on foreign technology has worked against the further development and maturation of the domestic innovation system (See Richard P. Suttmeir, 2002, for further discussion on this issue regarding China).

Brazil, Russia and South Africa are strong in natural-resource-based industry. In Brazil, Russia and South Africa manufacturing has decreased in relative importance and weight; international competitiveness has faltered. Brazil and Russia have shown stagnant performance in world manufacturing of high-tech products. South Africa's presence in

competitiveness is being brought to the fore in all international S&T cooperation programmes. The proportion of total R&D financed by industry has increased relative to the government share in almost all OECD countries. Industry funds almost 60% of OECD R&D activities and carries out about 67% of total research.

2 China has been the world's fastest-growing economy in the last twenty five years, with a high investment rate. Its spectacular growth is certainly related to the competitiveness of its manufacturing system. It has doubled its share of global manufacturing in value-added terms and almost quadrupled its share of the world's high-tech production. High-tech products already account for 36.5% of Chinese exports (2005). China is also doing better in increasing R&D expenditure, which rose from 0.6% in the mid-Nineties to almost 1.9% in 2006. Domestic demand is leveraged better so as to create innovative strengths in selected sectors, particularly where local enterprises have benefited considerably from the preferential treatment accorded to them by the state.

high-tech is quite small. The share of high-tech sectors in manufacturing (value added) ranges between 14% and 17% in Brazil, Russia, India and South Africa. The corresponding figure in China's case is 35%. Similarly, whereas employment in high-tech sectors stands at 19% in China, it still hovers around 8.5% of total manufacturing employment in Brazil, Russia, India and South Africa (Coutinho & Laplane, 2006).

Evidence exists that even in India's case the better-performing sectors, such as pharmaceuticals and automobiles, benefited significantly from the policy of selective protection which the government continued to pursue even up to the end of the Nineties. Analysts often forget that India experienced a steep decline in manufacturing during the Nineties, with the capital goods industry in particular suffering a lot in that decade. Although it has picked up somewhat in recent times, the pace of growth of manufacturing is still on average on a par with that of GDP growth. India's manufacturing capability in high-tech sectors is still relatively small. With the exception of a strong chemical base, the intermediate goods base is still relatively quite small. In most industrial sectors, India remains weak in industrial R&D capabilities, basic engineering and design activities. And employment of highly qualified human resources is still very much biased towards the low-value-added segments of IT-related services.

As regards the rest of India's economy, the world of S&T and innovation has undergone a change in its ideology and relations — as a result of the fact that the agenda of external liberalisation caused a significant decline in the breadth and depth of imported know-how, the loss of market control to foreign enterprises in a number of sectors, a decreasing trend in allocation of financial resources to R&D, a pattern of significant contraction of expenditure on the development of engineering, design and R&D capabilities in public- and private-sector industry, the continued problem of very weak R&D in the higher-education sector, the persistence of internal and external brain drain, and the rapidly emerging integration of available human resources in S&T by foreign enterprises. The outcomes of this new alignment are more myopic than before in terms of deployment/achievement of S&T to improve human conditions in India (See Dinesh Abrol, 2006, for further discussion on the same issues of concern).

Brazil's economy has shown irregular and mediocre performance, well below its potential[3]. Brazil is still mostly a primary-commodities exporter in spite of decades of government R&D effort. If we also look at Brazil's human resources in S&T not in absolute terms, but in relation to its population, they remain quite scarce. Brazil had only 168 scientists and engineers per million people in 2000; South Korea had 2 139. The Nineties saw a significant break with the trend of the previous two decades (i.e. that of increasing resources applied to scientific training) due to the main agency's budget being frozen. Despite growth in the production of Brazilian scientific publications, such output remains marginal in terms of world production. Although Brazil has an improving scientific system (with a good international rating), its success stories are concentrated in agribusiness. Patent activity is weak: some key sectoral innovation systems disintegrated in the Nineties. What is considerably important in Brazil's case is that the Cardoso government also privatised state-owned firms and reduced funding for or privatised

3 Brazil's share of world exports has stagnated, although there has been a slight improvement recently.

public research institutions, and the negative impacts of this policy show up in the form of a lack of sufficient innovation capacity for solving the problems of social inequality and dependence faced by the new government of Lula (See Noela Invernizzi, 2005, and Dahlman, 2007, for further discussion on the state of health of Brazil's national innovation system).

Russia used to be a scientific and technological superpower. During the Nineties its economy declined considerably, with a 15% drop in GDP. The economic crisis that followed the collapse of the Soviet Union in 1991 meant that the scientific and technological infrastructure also suffered quite a lot of damage, mainly due to the collapse of the former technology-transfer mechanisms and a significant contraction of the human resources in S&T which the country's economy had earlier employed. Most firms resorted to importing technology, capital goods and components. As a result, while Russia produces much basic science, there are few commercial applications. After the deep crisis of the Nineties (disorganisation of the state-socialist economy) oil prices have helped the Russian economy to recover. Russia has a strong position in higher education, with a powerful scientific system particularly dedicated to space- and defence-related activities; expanding R&D expenditures and patent activities are related to the former specialisations. Dahlman (2007) suggests that Russia is in fact de-industrialising, as the large foreign exchange inflows are generating Dutch-disease effects. Virtually everything other than natural resources is losing competitiveness. Russia is now growing by exploiting its large natural gas and petroleum reserves.

South Africa is, relatively speaking, very weak in R&D and innovation activities. The 2005 UNESCO Science Report points out that during the Nineties the African continent's two science giants — Egypt and the Republic of South Africa — encountered difficulties in maintaining their previous level of performance. South Africa's new R&D strategy (NR&DS) follows on from the innovation strategy in South Africa to address the "innovation chasm". As identified in South Africa, this chasm is the gap between research as such and the products and services created from technologies developed from that research. It follows on from the White Paper on S&T published in 1996. South Africa's new R&D strategy is based on establishing and funding technology missions critical for promoting economic and social development, and these include biotechnology; information technology; technology for manufacturing; technology to leverage knowledge and technology for value addition to natural-resource sectors; and technology for poverty reduction. In addition to the need to increase the numbers of young people choosing science as a career, there is a special focus on increasing the number of women and people from previously disadvantaged communities entering and remaining in the sciences.

To wrap up: the impact of neo-liberal policies for science, technology and innovation on the process of development during the Nineties has been quite clearly in line with what was predicted by all academics opposed to innovation regimes being transformed, with unequal integration of the BRICS group countries, in the name of the Washington Consensus. Inequality has been widened. Development problems have been aggravated. As most countries in this grouping underwent privatisation of transport, post,

telecommunications, harbours, airports, electricity, gas, energy, water supply, etc., exclusion from access to public services and from participation in the development process now applies not only to the poor but also to micro-, small and medium enterprises. Furthermore, since common elements of public policy have been reducing public expenditure as a proportion of GDP, moving away from public provision of services towards more market-oriented approaches and governments contracting with private agents to supply public services, a significant part of cost reductions in sectors dominated by public-sector enterprises was basically achieved via reductions in R&D spending and in general technology development activities[4]. This has adversely affected the diffusion of new and emerging technologies.

Adverse impacts are being felt on the orientation and direction of S&T efforts across the board worldwide in the fields of agriculture, health, energy, etc. These negative impacts are, on the one hand, a result of the intended diminution or closure of large-scale technological and engineering capabilities in formerly publicly owned enterprises/international agencies, and, on the other, a consequence of transnational corporations taking over the cheaper and easily accessible remaining publicly funded S&T efforts of the "emerging economies" in the South. This new kind of global integration is also leading to a reduction in R&D focused on poor people's problems, diminished possibilities for broader participation in decision-making, a decrease in R&D focused on creation of public goods, and a drop in research focused on achieving national self-reliance goals, etc.

Given the abovementioned conditions of liberalisation, privatisation and neo-liberal globalisation, it is not surprising that in most of the BRICS group countries the following common elements of change in the orientation of their national S&T policies have prevailed since economic reforms of the Washington Consensus variety began: increased mobility of students and researchers, largely skewed towards the USA, fluctuations in the funding of science facilities, scaling-down of large-scale technological and engineering capabilities in formerly publicly owned enterprises and laboratories, incorporation of S&T resources for private ends through finance-dominated intellectual property rights, self-financing of research, public-private partnerships having less public interest at heart, transnational integration of national S&T resources, a drop in research for achievement of technological self-reliance goals, reduction in the resources for R&D focused on poor people's problems, a decrease in the share of R&D resources meant for the creation of public goods, and diminished possibilities for broader participation in decision-making[5].

4 In fact, many public-sector enterprises (PSEs) which in the past possessed most of the engineering and design might of Brazil, Russia and India were privatised in a big way during the Nineties. In fact, much evidence exists that PSEs saved from being privatised in those three countries are performing better in terms of innovation and manufacturing.

5 University system mandates have been redefined, with an increased role for private tertiary-education institutions. Public universities and research institute systems were also realigned towards the performance regime governed by the private-finance dominated framework of intellectual property rights, technology transfer and market-governed selection of R&D priorities.

On the importance of an enabling policy environment for reaping the benefits of S&T cooperation

When it comes to the generation of public values flowing from S&T policies, what matters most is the institutional, cultural, political and economic conditions in which science, technology and innovation are produced and applied[6]. Governments, business organisations and social movements, all of them must nowadays address the issue of how they are going to achieve the common good via the S&T and physical infrastructure now being erected in the new situation. What pathways to ecological and social justice and sustainability using which development issues need to be tackled in the face of the challenge of the global problems the international community has recognised?

A change as substantial as that described above has, no doubt, a complex set of factors underlying it, but quite an important one among them is the emergence of a new form of international finance capital. The role and power of finance capital are evident in the formation of a new paradigm of development and management of S&T. The new paradigm is focused on the economic reorganisation of S&T in favour of a tilt towards private control through the introduction of the institutions of stronger intellectual property rights, self-financing of research, public-private partnerships for creation of private goods and transnational integration of national S&T resources in the name of global competitiveness and innovation leadership. Technologies that emerged, or experienced a breakthrough, in the Seventies and afterwards have been increasingly generated within innovation regimes that have incorporated new structures and practices oriented towards commercial applications, indicating a new relationship between public and private on the one hand, and between global and local on the other. Though not unrelated to the emergence of the power of these changes in the S&T landscape, multinational corporations have been switching to a global strategy as distinct from multi-domestic strategies using IT, something that facilitates intra-corporate networks and allows them to distribute R&D, manufacturing and marketing facilities worldwide in a number of different locations, with the ability to source key technologies/intermediate knowledge inputs internationally and to manage their value and profit-creating activities on a global scale.

In this new situation, therefore, science, technology and innovation policies nowadays urgently require reforms of a different kind so as to have a counter influence. At the level of firms, major effects come via privatisation of publicly owned enterprises or wider processes of industry regulation. In the new situation, at a time when the impact of global problems in all these countries is already being felt quite acutely, the world is also readying itself for the co-evolution of new large-scale technological systems and accompanying institutional innovations to achieve sustainable development. S&T performance is likely to depend significantly on localisation decisions to be taken by firms in these areas. If infrastructural investment is nowadays a main instrument for creating location-specific assets, then the global problems in the areas of climate change,

6 Public value failure occurs when neither the market nor public sector provides goods and services required to achieve core public values.

hunger and disease should certainly be deciding which assets are strategically important for these countries. These decisions and the factors that already affect them should become an important issue for S&T policymakers. For which business fields, and how policies can be shaped to create them, are an issue of local coordination. Coordination instruments are missing.

For example, if we wish to successfully tackle the challenge of energy provision and environmental protection without aggravating the problem of climate change any further, renewal of knowledge infrastructures under publicly owned utilities and services for communication, energy and environment constitute a major challenge in these countries today[7]. In this new situation, the issues of accessing, adapting and deploying foreign technologies are central to productivity growth for sustainable development in the above-stated areas, but as markets are opened up local firms are experiencing difficulties in technology acquisition, adaptation and improvement. Liberalising economic policies do not in themselves adequately create innovation capabilities. Free entry, improved access to finance, wider markets and greater flexibility do not automatically mean latecomers can gain. Markets perform poorly or not at all.

Even in the sphere of international cooperation in S&T this new paradigm is having an adverse impact on the orientation and direction of S&T. Efforts being promoted by the industrialised nations in the form of transfer of students and research personnel, or the access to knowledge and knowledge infrastructures, are also tending to reflect the force of changes in the S&T landscape being brought about by liberalisation, privatisation, deregulation and neo-liberal globalisation. Although the footprint of these negative impacts is being felt in the field of international S&T cooperation in general, it is much more starkly evident in the areas of agriculture, health and energy. The impact of changes in S&T organisation is being felt and hampering realisation of targets even in cooperation under the Global Research Alliance (GRA), where the identified global challenges are being targeted directly. Similar trends are evident in the field of agriculture, if the recent international assessment of agricultural science and technology for development is to be believed. Experience gained in the initiatives taken for vaccine development and tropical diseases at international/global level has also similar lessons to offer policymakers.

Priority-setting processes and mechanisms

It would be quite appropriate to state that while framing the vision and strategy of international cooperation in S&T to tackle the global challenges of poverty, disease, climate change, peace and security, we should not further the abovementioned trends in S&T through the joint approach process when making our contribution. In order to achieve the required policy coherence in the efforts being undertaken for development,

7 Large technology systems have often involved the construction of accompanying infrastructures: internet, information and communication technologies, new energy devices, automobiles, electricity distribution, aeronautics, highways and cable networks are good examples of such phenomena. The provision and economics of such infrastructures drive the rise to dominance of new radical technologies. In the case of core and long-term technological capabilities (radar, telecom, microelectronics, nuclear power, biotechnology, advanced aircraft, container transport, space-based communication, new materials), we tend to forget the roles of infrastructural organisations once technologies are fully developed.

we will have to tackle as early as possible the challenge posed by the transformation of S&T policies and emerging patterns of international S&T cooperation. Although we do need a lot of openness today, in order to meet the global challenges successfully it is also necessary to replace the influence of the Washington Consensus by a new international consensus, not only in respect of the orientation and direction of economic policies but also with regard to S&T policies, i.e. research policies, innovation policies, human resource policies and regulatory policies. Only then would we be able to move the world closer to working out, and contributing to, the pathways for achieving an ecologically and socially just order. The issues of development and the connected global problems would not be tackled appropriately if the EU also kept pushing neo-liberal policy elements at the various world forums. If we are to achieve an enabling policy environment which would allow us to maximise the positive impacts from international S&T cooperation, the EU must help a new paradigm to emerge in the place of the Washington Consensus. For a new beginning in the WTO negotiations, the EU can provide the countries of the South with room to tackle the agriculture crisis in a new format. This means that the EU would not be placing to the fore the interests of corporate agriculture. Regarding intellectual property, the EU can encourage not-for-profit and open-source models for generation and transfer of new technologies, so that the BRICS group countries can also contribute actively to generating solutions to global problems.

On the issue of the EU shaping specific instruments and mechanisms, it would be necessary to practice pluralism in the technological solutions and approaches to be followed for cooperation in expanding the technology platform concept, which seeks to involve business, government and universities in long-term technology development programmes (extension of not-for-profit models, e.g. Drugs for neglected diseases initiative (DNDI), open-source models for technology development, etc.). Similarly, efforts are already under way, in the form of bilateral efforts by EU Member States, to establish new structural mechanisms for international cooperation in S&T where the emerging economies are willing to become equal partners in developing joint efforts with Europe. Efforts should be made to extend this concept to development of solutions for tackling the nation- and region-specific dimensions of global challenges. At multilateral level the EU and Member States can initiate efforts to establish a treaty that would aim to expand multilateral access to S&T for development of technological and institutional solutions to respond to the global challenges (see John Barton and Keith Maskus, 2004, for a discussion on the economic perspectives of a multilateral agreement on open access to basic science and technology).

Identification of the development-related global challenges: some suggestions

In our view, the development-related global challenges of food security, health and medicine and sustainable energy use nowadays constitute a key priority for international S&T cooperation to be forged between the BRICS group countries and the EU. The challenge of development for international S&T cooperation has been identified at various international forums. Twice the present aggregate level of output is needed to support eight billion people. Strains on ecosystems are growing and can grow further if

there is no shift to more appropriate methods of food production. Biofuels and agribusiness promote contradictory solutions to the problems of development and the global challenges of energy use. There is a need to move away from single-commodity-based technological solutions. India and China still have over fifty percent of their population in rural areas where the agriculture sector provides livelihoods. As more attention is needed to develop resource-conserving technologies, international S&T cooperation should approach this development problem in terms of finding a systemic solution to global problems facing the world in the field of hunger, poverty, environmental pollution and climate change.

In the area of health, the issue of tackling the challenge of neglected diseases that affect the poor continues to face the world even after the introduction of a strong intellectual property regime. The 10/90 problem in R&D persists. In the ongoing international negotiations on public health, intellectual property and innovation at the WHO, the EU can take the initiative and push for a treaty for R&D on public health where open-access and open-source models of drug innovation can be given a prominent place in the mechanisms to be used to attack the problem of global health. In the field of public health, by undertaking research on neglected diseases and a far more systemic approach to health systems development, the EU can develop a major programme of international S&T cooperation with the BRICS group countries and create a win-win situation for itself and the world as a whole.

Similarly, as regards sustainable energy use, the EU can do a lot by proposing to develop clean technologies in a joint programme with the BRICS group countries. The energy problem needs an integrated strategy; problems of transport and habitat planning are closely connected. In the joint BRICS-EU programmes, lifestyle changes and systemic innovations in respect of energy conservation must receive a new impetus in the international S&T cooperation programmes.

Since the time is ripe for development of joint EU-BRICS programmes, the EU can initiate an international dialogue on the abovementioned development. Because tomorrow we may be too late, the EU should take steps to get the world community to recognise S&T for development to be a global challenge in itself.

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Health and quality of life

Global health challenges: Africa's health crisis and key research imperatives

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Abstract

The health of Africans is of global concern, as improvements in health indicators observed even in other low and middle income countries (LMICs) have not been achieved in Africa. With the exception of malnutrition in children under-5 years of age in South Asia, all key health indicators for Africa are at much worse levels than in any Asia or Latin America and have shown no significant progress since the 1990s. In fact, without dramatic, meaningful and sustained change, it is likely that Africa will not achieve any of the Millennium Development Goals.

Africa's health crisis starkly illustrates current complex global public health challenges exemplified by rapidly widening health inequalities, and unprecedented emergencies such as the pandemic of Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS), Tuberculosis, Malaria and other communicable diseases. In addition, countries in Africa are experiencing high levels of violence and injuries and an emerging epidemic of chronic diseases, the latter earlier thought to be mainly confined to the better-off regions of the world. This exerts a double burden on weak and often deteriorating public health systems.

This bleak situation demands a reappraisal of existing priorities in health policies and research. Global health research needs to focus much more on both the growing divide in health status between the world's rich and poor, and on the unacceptable gap between unprecedented knowledge about diseases and their control and the implementation of that knowledge (the "knowledge-implementation gap"). Directed and innovative research is needed to analyse the causes of this situation and to point towards solutions at the global and local levels, both within and outside the health sector – given that inequitable economic globalization is leading to greater disparities in wealth between and within countries.

In this paper, we present a brief overview of the health crisis in Africa describing its scale and reflecting on the causes of the crisis. Drawing on this, the importance of prioritizing research on the underlying determinants of population health is emphasized. We further aver that there is need for a guided focus on health systems research and research on effective public health initiatives that could spur improvements in population health.

Key words: Africa, Global Health, Health Research, Health Systems, Public Health, Globalization.

Introduction

Population health is a global challenge, and for Africa a critical challenge. Even though this region of the world accounts for only 14% of the world's population, it bears a disproportionate 40% of the global burden of disease (Lopez et al, 2006). Africa is further disadvantaged by being the poorest region of the world. Whereas improvements in health outcomes are evident globally, Africa lags behind showing only ephemeral progress in enhancing its health status (Simms et al, 2001; Sanders et al, 2003). In fact, a reversal of many of the gains made in health status in this region has occurred for many countries over the last few decades (Simms et al, 2001; Sanders et al, 2003; Sanders et al, 2005).

Comparatively, with the exception of malnutrition in children under-five years of age in South Asia, all key health indicators for Africa are at much worse levels than in Asia and Latin America and have shown little or no substantive progress since the 1990s (Sanders et al, 2003). Without dramatic, meaningful and sustained change in progress, Africa will not achieve any of the Millennium Development Goals. Yet, health research has failed to address fundamental questions such as "why health and health care inequities continue to grow despite greatly increased global wealth, enhanced knowledge and more effective technologies" (McCoy et al, 2004).

The purpose of this paper is twofold; first to present an overview of the health crisis in Africa describing its scale and providing some incisive reflections on the causes of the crisis. Secondly, it will outline, based on the health challenges and identified causes, key research imperatives for global health that are especially pertinent to Africa. The importance of prioritizing research on the underlying determinants of population health will be emphasized. We also argue that there is a pressing need for a focus on health systems research, especially research on effective public health initiatives that result in better population health.

Africa's health crisis

Even a cursory analysis of the status of health in Africa relative to the rest of the world portrays a substantial divide in population health. The levels and trends of two health status indicators, Infant mortality rate (IMR) and Life expectancy at birth (LE) support this observation. IMR in sub-Saharan Africa for example averaged 101 per 1000 live births in 2005 (higher in some countries), compared to about half this estimate (52 per 1000 live births) worldwide (World Bank, 2006). The rate of infant deaths in Africa was therefore many times more than countries such as Singapore, Sweden, Japan, Hong Kong and Iceland, with IMRs less than 3 per 1000 live births.

LE presents an even bleaker picture haven dropped to below 40 years in nine African countries- Botswana, Central African Republic, Lesotho, Malawi, Mozambique, Rwanda,

Swaziland, Zambia and Zimbabwe (World Bank, 2006). Reversal in LE is exemplified by a country like Zimbabwe where LE was 34 years in 2003, compared with 52 years in 1990.

Africa's health crisis is attributable to rapidly widening health inequalities and unprecedented emergencies such as the pandemic of human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS), Tuberculosis, Malaria and other communicable diseases. The majority of countries where LE has decreased have a high prevalence of HIV, affecting in particular the 15-45 age group (Sanders et al, 2003). At the end of 2006, the number of HIV infected people in sub-Saharan Africa was estimated at 24.7 million, almost two-thirds (63%) of the total of HIV infected people globally (UNAIDS, 2006). Approximately 2.8 million additional people were infected with HIV in 2006, surpassing the combined number of new infections in all other regions of the world. 2.1 million deaths in Africa were attributed to HIV, accounting for 72% of global AIDS deaths (UNAIDS, 2006). In the absence of massively expanded prevention, treatment and care efforts, it is expected that the AIDS death toll will continue to rise. The social and economic consequences HIV/AIDS are already widely felt throughout Africa, not only in the health sector but also in sectors dependent on human resources such as education, industry, agriculture, transport, and the economy in general.

In addition, countries in Africa are experiencing emerging epidemics of injuries and chronic diseases, the latter earlier thought to be mainly confined to the better off regions of the world. The surge in the disease burden attributable to chronic diseases is profound. In South Africa for example, Ischaemic heart disease, stroke, hypertensive disease and diabetes mellitus account for an aggregate 20% of total deaths while comparative risk assessment of selected risk factors for diseases underscored the population-attributable fraction of risk factors of chronic diseases such as high blood pressure, tobacco smoking, unhealthy diets, alcohol abuse and physical inactivity (Norman et al, 2007). Furthermore, there is empirical evidence to confirm that chronic disease is now a problem for young African adults and increasingly affects them earlier than it formerly did (Igumbor and Buso, 2006). This imposes a double burden on weak and often deteriorating, public health systems in Africa which must both provide health care services that manage infectious diseases and also health promotion strategies that address them and also chronic diseases.

Moreover, many African countries continue to be embroiled in conflicts resulting in complex emergencies affecting livelihood and further heightening the demand for health care. At the same time, health service delivery is severely disrupted in such situations. Even in non-emergency situations, fiscal stringency as a result of debt, macro-economic reforms and harsh conditionality has led to chronic underfunding of health services. This, together with the loss of health human resources from HIV/AIDS and out-migration, has resulted in near collapse of health systems in many African countries.

In summary, poverty, the HIV epidemic, weakened health systems and continued conflict in a number of countries, have all contributed to Africa's health crisis.

Key global health research imperatives

Africa's health crisis demands a reappraisal of existing priorities in health policies, expenditure and research. The funding gap, (dubbed the 10:90 gap), shaped essentially by commercial interests and the inadequacy of local funds, whereby only 10% of global health research funds are allocated to the problems that account for 90% of the global burden of disease is unacceptable. One key imperative of is to push the global health research agenda towards equity. Increasing development assistance, cancelling unfair debt and reforming unjust trade paradigms will also be an important part of the solution (McCoy et al, 2004).

Whereas clinical and biological research should not be jettisoned, there is need for much greater balance between the inordinate levels of funding to this type of research and that to research on the social, economic and political determinants of ill health. More emphasis must be given to the framing of research questions that address practical health systems development with a focus on effectiveness. It is striking that only cursory attention has been paid to exploring questions about "why some primary health care programmes work and others do not" or "how to best organize public health interventions to get maximum benefits". Research into "effective mechanisms for global resource redistribution"; "how health equity can be protected from market failures; and the design and financing of systems including improving access to good quality care" are needed (McCoy et al, 2004). However, it is difficult for public health researchers to pursue such research given the meagre funding for "health systems research" that addresses the "how" questions in health (Chopra and Sanders, 2000; Sanders and Haines, 2006).

The fact that in LMICs, a derisory 0.017% of health expenditure is spent on research reduces the potential of local researchers to provide any significant contribution to the research agenda in Africa (AHPSR, 2004). The implication of this is an "imbalance in power" between researchers in Africa and those in richer countries (McCoy et al, 2004). Any effort to map the distribution of research funds for health problems between research institutions in rich and poor countries will highlight the disproportionate benefit to researchers in richer countries. This inequity in research funding will need to be tackled if research is to be geared towards addressing the key research questions relevant to Africa's health challenges. The best ways of doing this are not clear and there is need for further research in this area, including an exploration of funding policies and patterns of donors and international agencies, together with documenting innovative responses to the challenges to developing research capacity in LMICs.

Thus, health research needs to focus much more on both the growing divide in health status between the world's rich and poor, and on the unacceptable gap between unprecedented knowledge about diseases and their control and the implementation of that knowledge (the "knowledge-implementation gap"), especially in Africa. This "unconscionable gap" between knowledge and its use is likely to remain unless research and academic institutions actively promote "implementation research" and policymakers insist on robust monitoring and evaluation as a sine qua non of programme implementation (Sanders and Haines, 2006). To this end, it is encouraging that

educational institutions have began to build capacity in the conduct of health systems research (Alexander et al, 2008) but much more has to be done in this area.

Civil society organisations (CSOs) and a few research initiatives have begun to promote relevant research directions for Africa and can contribute in influencing, generating and using such research. The disease control priorities project (DCPP) is a relevant initiative that should inform the research development agenda in global health, as are many activities of civil society organisations. Innovative ways of promoting civil society participation and partnership in health research are needed that would see CSOs more involved in "influencing commissioning and priority setting, becoming involved in the review process, developing enhanced links with academic researchers and in research production by changing funding rules" (Sanders et al, 2004).

Conclusion:

In conclusion, global health research needs significant re-orientation in order to be more responsive to global health needs. Africa's health crisis makes it imperative that research should prioritise examining the reasons for the increasingly uneven burden of ill health both between and within countries; assessing the impact of public health interventions; determining factors that predict success of interventions under normal conditions; and analyzing the type of social mobilization that would lead to policy change to improve the social determinants of health and transform weak health systems on the continent.

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Health inequities and urbanisation. Implications for health systems research.

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Introduction

The social and physical environments have long been recognized as important determinants of health and the rapid change in these environments is affecting people worldwide. Despite major advances in knowledge, unprecedented gains in wealth and important policy commitments such as the MDGs, health inequities both within as well among countries and regions are deepening (Marmot 2006;UNDP 2005). These inequities not only affect the poor but *the whole* of society (Wilkinson 1996;Wilkinson 2005)

This paper first describes the unprecedented challenge posed by the rapid urbanization of poverty and the deepening inequities now seen within and among urban settings (KNUS 2007). The paper explores in particular some implications of the increasing informalisation of the economy for worker's health and safety from a gender perspective. It argues that there is a need to develop a value-based systems' (or 'integrated') approach of health in order to address not only the proximal risk factors but above all the upstream, structural and underlying determinants. It focuses the attention on the role of meaningful participation, empowerment and participatory governance in these approaches and explicitly the need to tackle issues of participation, equity, governance, and the politics of power, decision-making and empowerment in different contexts. The paper then examines the implications for health systems' research and argues that there is an urgent need to reorient research priorities, to develop a system's analysis of health and health inequities and to enhance interdisciplinary and transdisciplinary approaches in research. It is essential to acknowledge the importance of context, of values, the politics of power and of the unequal access to resources in research partnerships. The paper concludes by urging the EC to address these challenges that have been neglected so far. This implies in particular the need to strengthen cooperation with the less developed countries in Africa.

Urbanization

The world is becoming increasingly urbanized and poverty is also becoming an increasingly urban phenomenon. If current demographic trends continue, the world's urban population will increase from 2.86 billion to 4.98 billion by 2030, when about 60 per cent of the world's population will live in urban areas[1]. Most of the projected growth in the next two decades is to take place in the less developed regions of the world, and cities and towns will absorb 95 percent of urban growth and will be home to almost 4 billion people, or 80 per cent of the world's urban population by 2030.

The growth of densely populated, informal or squatter settlements often equals urban growth. According to recent projections, the population living in informal settlements ('slums') in low

[1]Official statistics on urbanisation rely on dynamic country-specific designations as various countries employ different methods to identify 'urban' place (population size, economic base, administrative criteria or functional definitions) and the concept of urban may also change over time (Vlahov et al. 2007).

and middle-income countries is likely to double in less than 30 years (UN Millennium Project 2005; UN-Habitat 2006). It is worth noting that at the end of the nineteenth century less than 3 percent of the world's population was living in towns and cities (Weber, 1899), and that Africa and Asia were still almost wholly rural in 1950. In the past 50 years a world that was predominantly rural has been transformed into a world in which most people now life in urban centres and there is a need to examine the factors that continue pushing and pulling people from the rural areas to the cities. At present, the annual urban growth rate in Africa has become more than twice the global average which is comparable to urban growth rates in the towns of 19th century Europe. By 2030 its urban population will exceed the total population of Europe (UN-Habitat 2006).

The following trends are also relevant. The first is the increasing concentration of the biggest cities in the world – 'Metacities', with conurbations of over 20 million people. The second is the increasing importance of natural population growth in urbanisation processes of medium size cities, of less than 500,000 inhabitants, rather than rural – urban migration and the reclassification of many rural areas to urban areas. Already more than half of the world's urban population lives in cities of less than 500,000 inhabitants and almost one-fifth lives in cities of between 1 and 5 million inhabitants. The third trend is the increasing transnational urban migration (South-South and North-South) due to globalization, conflicts, political instability, environmental degradation and the massive rural-to-urban migration in China concomitant with the majority of migrants without urban citizen's rights (Balbo and Marconi 2006; Zhang 2008)

This rapid urbanization is unprecedented and accompanied by severe developmental problems. While there are important regional differences – in many Sub-Saharan cities the people living in informal settlements lacking basic infrastructure already accounts over 70 percent of the population -, poverty is increasing, and living conditions are deteriorating in *all* cities.

People are exposed to a variety of health risks that are inter-connected and often produce synergy in health effects as well as multiple disease-outcomes. However, exposure, risks and health impact differ according to key relational mechanisms such as social class, gender, age, occupation, education, migrant status, ethnicity/race, power/influence and geographical place (CDSH 2007). Already in the early 1980s Rossi-Espagnet drew attention to the fact that the urban poor are at the interface between underdevelopment and industrialization and that their lifestyle and disease patterns reflect the problems of both. While still exposed to the traditional health hazards related to poverty, unemployment, malnutrition, poor shelter and inadequate environmental and social services, the urban poor are also more exposed to hazards related to "modernization", such as unhealthy urbanization and pollution - while the lack of social support systems in cities and social exclusion increases the risk of mental health problems (Rossi-Espagnet 1983;Rossi-Espagnet 1984).

A study in 23 countries highlighted the fact that generally inequalities are higher in urban areas relative to rural with the exception of countries in which rural economies are structured around plantation agriculture (Mitlin 2004). This is reflected in strong gradient from rich to poor in life expectancy. In Nairobi for instance the average infant and child mortality rates are lower than in Kenyan rural areas, however in the informal settlements of Kibera and Embakasi these rates are three to four times the Nairobi average (APHRC 2002). In Sub-Saharan cities, children living in informal settlements are more likely to die from respiratory and waterborne illnesses than children in rural areas (UN-Habitat 2006). Many urban settings

worldwide face pervasive problems related to a rapidly increasing socio-economic-cultural differentiation, deteriorating living conditions and social polarization. The deepening inequity and polarization both *within* as well as *among* urban settings appears to be increasingly associated with conflict and insecurity.

Throughout history cities have provided new opportunities for income growth, improved living conditions and health development (Hall 1998; Leon 2008). However, current urbanization differs from what the world has experienced so far and this has implications for health equity, sustainability and development policy. Firstly, most problems soon will have to be addressed in complex challenging urban environment that also reflects deepening global and national inequities. Secondly, most countries in Sub-Saharan Africa and Asia either have no commensurate economic growth or no effective redistributive measures to alleviate poverty (Simon 1997). The depth of poverty is often worse in deprived informal settlements in cities than in rural communities. Thirdly, the capacity to address these arising challenges in a context of climate change, global economic and energy crises, food insecurity and weak global governance appears limited and demands urgent strengthening.

Informality, insecurity and health inequity

As urban growth rates in some cities equals those of the towns in 19th/early 20th centuries in Europe, many similarities exist with respect to the developmental problems, living and working conditions common in many European towns of that period (Szreter 2005). In many cities urban services and infrastructure have not kept pace with rapid urbanisation and an increasing proportion of the people in urban areas will live without adequate social infrastructure, especially housing, water supply, drainage and sanitation facilities (People's Health Movement et al. 2008).

A critical difference, however, is the fact that rapid urbanization of the 20th/21st century in many cities has not been accompanied by a similar growth in employment and production activities. The recent waves of economic reforms in many poor countries have added to the complexity of informal labour markets, where high and sustained growth rates are not necessarily accompanied by increased growth in formal employment (Guha-Khasnobis and Kanbur 2006). In both poor as well as rich countries, there are now more "flexible" employment arrangements, fewer institutional protections, and greater job insecurity (Hogstedt et al, 2007). There is also increasing evidence that the expansion of precarious employment and job insecurity over the past three decades has had serious adverse effects on workers' health, both directly and indirectly (by undermining regulatory and other protections) (Kivimaki et al. 2003; McDonough 2000; Quinlan et al. 2001a; Quinlan et al. 2001b; Vosko 2003).

The number of informally employed, unprotected and low-income workers is rapidly increasing. Gender is an important variable. Gender-based inequity -found across nations, cultures, religions, regions of the world and at all levels of society -explains why women and men come to accumulate different levels of wealth, cultural resources, political power and decision-making in economic and social affairs (Social Watch 2008). It influences responsibilities, benefits and vulnerability and it conditions the types of exposure at the workplace with consequent health impact and health inequalities (WHO 2006). While women – relative to men – have been restricted in their access to jobs, from 1960 onwards, and in particular over the last two decades, they have increased their participation in the world of

remunerated employment (Social Watch 2008;UNRISD 2005;Wamala and Kawachi 2007;World Bank 2001). However, these employment gains are often precarious and many women work in the informal sector of the economy (Arroyo Aguilar et al. 2005;Cedeno and Barten 2002). Work is often invisible or carried out under bad working conditions. It often entails no direct payment, is excluded from social protection and has implications for workers' health and safety. Moreover, the position of women influences child health outcomes (Acevedo 2002; Barten et al. 2008; Social Watch 2007). Women are also less organized in unions (Kolk et al. 1999; WHO 2006). Another challenge is the rapidly increasing number of illegal migrants, who add to the low-income population in cities, often end up in hazardous work and lack rights to health care, education or decision-making.

Informal work is of course not limited to informal urban settlements (Werna 2001). However, workers that survive in the informal economy in urban settings are a more *vulnerable* group. The workers' health and that of the wider community cannot be considered in isolation of the rapidly changing context in many cities.

Contextualising the evidence

It is important to place developments at city level in larger national and global contexts (UN-Habitat 2004b). Economic, social, political, spatial and demographic dimensions of globalization processes impact upon cities. An important institutional impact of globalization on cities – and therefore relevant to the topic of this paper - has been the weakening of national and local public institutions, relative to the arrival of powerful, informed and decisive multinational external private sector companies. Effective government power had already been reduced since the 1990s, when essential public services, such as water supply, sanitation, waste collection, social services etc. in many countries were privatized and outsourced from government to private companies. The shift to more precarious patterns of employment and disorganized working settings, will also have an impact on the governance of cities as public authorities will obtain less revenue to provide for public services (UN-Habitat 2004a).

Furthermore local authorities are under pressure to attract private investment in order to create job opportunities and generate income in the city, while external private-sector companies enjoy wide freedom to establish themselves where conditions such as wage rates, tax breaks and other incentives, and national regulatory framework are most beneficial. When these conditions change, or become more favourable elsewhere, the companies can quite easily move to another more favourable location (Barten et al. 2006).
As a group women suffer more from competitive pressures and are usually the first to be laid off when labour-intensive manufacturing jobs move to even lower-wage countries (Fussel 2000; Joekes 1995). They often have limited possibilities for skill acquisition and advancement and have inadequate security coverage in terms of old-age pensions, whereas their work as carers of family-members often continues into old age (ILO 2002;Social Watch 2007). In some rapidly industrializing economies or export-processing zones, women's share of employment has fallen and apparently no sustained improvement in labour market status has been achieved (Berik 2000; Fontana et al. 1998; Jomo 2001). Although the relevance of participatory governance, capacity enhancement and empowerment is increasingly recognised, these changes in trends imply that in fact a fundamental shift in employment relations and power is taking place. This has implications for long-term health outcomes at individual and societal levels (Marmot et al, 1997).

The major consequences of these changes are increased urban poverty and a widening gap between the rich and the poor in cities. The twin processes of increasing poverty and deepening inequity need to be understood as a process of increased socio-economic differentiation in cities (National Research Council 2003) and this also occurs in cities of more developed economies, where this differentiation is significantly increased by transnational migration (Beall 2002)

Participatory governance, information and health systems

Considering the complexity and magnitude of health, poverty and environmental issues in cities, it is clear that improvement in health and health equity needs to move beyond fragmented interventions that focus on single issues only. These conditions are not addressed by health systems that prioritize single issues, vertical disease-programmes, curative care above prevention or that focus on changes in lifestyle only. The mere presence and access to health services is inadequate to address health inequities and technological solutions are insufficient to address these health challenges (see Box 1).

Box 1. Moving beyond a symptom-treatment mode…?

Environmental lead exposure of children in low-income neighbourhoods in Managua has since long been a neglected urban health problem. Already in the 1980s several children died of lead poisoning and hundreds of children upon examination appeared to have unacceptably high blood lead levels (Barten 1988;Barten et al. 2008). They were living in cottage factories involved in the recycling of car batteries. In those years, the population of the capital city doubled due to the tidal wave of refugees from the war-zones in the rural area. Many people ended up working in the informal sector as a survival strategy. While the war and trade embargo created a high demand for car batteries, water was rationed and hygiene therefore limited. Malnutrition increased the vulnerability of young children. Thanks to the preventive focus of the universal health care system a screening of all children living in the vicinity of the car-battery factories was conducted despite severe resource constraints in order to identify children at high risk. However, and as raised by the Commission on Social Determinants of Health (Solar and Irwin 2005), "what sense does it make to cure a person and then to send him or her back to the same environment that caused the illness in the first place…" Participatory action enabled a better understanding of the fundamental issues at stake and the need to address this problem at all levels.

Improvement in health and health equity demands not only change in physical and social environments of cities, it also demands an *integrated* long-term multi-sectoral approach which takes into account the wider socio-economic and contextual factors affecting health. Integrated or multi-level approaches that involve the public sector and civil society should address not only the immediate, but also the underlying and particularly the basic causes at societal level of related health issues (Barten et al. 2006; KNUS 2007).

Current health policy has become increasingly verticalized and tends to prioritize short-term, compartmentalized thinking while an evidence-base is often found lacking. Also, trade in health services reduces the capacity of national health systems to address the abovementioned issues in an integrated way, as it reinforces a biomedical model of disease and increases

fragmentation. Priorities in global health policy are often set at international level (Ollila 2005).

Participation is considered crucial to the social transformation necessary for development as, among other factors, it would contribute to building ownership and commitment, to shaping avenues for involvement in decision-making processes and to allowing for sustainability of development processes, outcomes and decisions (Stiglitz 2002). Although the relevance of participation has been recognized by many agencies, in practice it has been more difficult to achieve and often took place in name only (Arnstein 1969). Political commitment for long-term participatory planning processes is limited in a context of limited resources and donor dependency. In order for comprehensive approaches such as healthy settings to address the upstream determinants of health inequities effectively and at multiple levels, they need to tackle issues of participation, governance and the politics of power, decision-making and empowerment explicitly (Barten et al. 2006).
Civil society has grown stronger in many countries and urban social movements may be important agents for ensuring participatory governance and more inclusive and effective public policy (Appadurai 2001; Fainstein and Hirst 1995). Also, the Commission of the Social Determinants of Health advocates for a global agenda and movement in order to enhance the social determinants of health for reducing health inequities.

It is worth noting that information systems – the capacity to measure the inequalities in population health – was a critical factor in cities of 19th century Europe that triggered redistributive public policy (Szreter 2005). However, information systems in many countries often do not capture the living and working conditions, environment and health status of populations living in unplanned and informal urban settlements (David et al. 2007). Research and knowledge have to play an important role.

Implications for research

Equity, solidarity, universality and access to good quality care have long been common values and principles that have oriented health systems' development in Europe (EC 2007). Firstly, there is a need for achieving consensus on a rights-based approach to health improvement and the reduction of health inequities. These values should orient a EU strategy and response to the abovementioned health challenges.
Secondly, there is a need for a wider understanding about health. Health is more than the absence of disease and although the presence of and access to health care systems are essential, these are insufficient if living and working conditions do not improve.
Thirdly, there is a need to enlarge the focus and to move beyond a 'symptom-treatment mode' towards a system analysis of health that analyses the upstream, underlying and structural determinants of population health and not only the individual proximal risk factors (Lawrence 2003;Pearce and McKinlay 1998). A system analysis of health differs from an analysis of health systems. It involves a set of agents and processes, change over a large period of time and the important historical, social, cultural, political determinants.
Fourthly, there is an urgent need for redefining research priorities and for identifying most strategic gaps in knowledge. Research should be made more responsive to the challenges of deepening inequities and should pay more attention to the real determinants of health inequities at upstream population level. To date, biomedical research on specific diseases has dominated – while the linkages between poverty, urbanization, employment, working conditions, urban environment, migration and health equity have not been acknowledged or

made explicit in the MDGs, and information on the scale of these problems and their health impact is still limited.
It is particularly important to strengthen the evidence-base of policy and to look into the role of public policy. There is still a large empty research agenda on these topics. This implies the need to move beyond the study of specific diseases and to study the reasons of planning failures as well as of effective policies and actions at national, EC and global level. Comparative studies may enable relevant lessons to be learned.
Fifthly, there is a need for a different approach and for appropriate methods to evaluate the major determinants of health at the population level. This implies the need to mobilize knowledge from different disciplines, to better integrate the natural and social sciences and to engage with different knowledge systems. So far, disciplinary research has dominated and there is a need to develop interdisciplinary and above all transdisciplinary approaches. Knowledge institutions have a crucial role facilitating this.
Also, there is a need for countervailing knowledge and for different approaches in research cooperation in order to increase relevance of research for reducing health inequities. What are the methodologies for agenda setting, the modes of conducting research, of research cooperation? To what extent is built on lessons learnt and earlier work? Who is involved in defining the research agenda and who decides? It is equally important to build new networks and to strengthen existing ones in order to ensure impact of research on society e.g. by developing the research skills of civil society organisations and by developing participatory action research. It is worth noting that within the framework of the INCO DEV programme relevant instruments have been created that enabled some of these essential preconditions to develop. Finally, as joint learning and coalitions probably comprise the central features that will allow knowledge to contribute to improve strategies to address these global health challenges, it is essential to acknowledge the importance of context, of values, the politics of power and of the unequal access to resources in research partnerships.

Summarizing, the problems of the urban social and physical environment posed by the current trends of urbanization and uneven development are immense and still largely neglected. Consensus should be achieved on a value-based approach to health and on a newly integrated or systems approach in public health that above all addresses the upstream underlying and structural determinants, and not only the proximal individual risk factors. There is an urgent need for global health research to address the upstream determinants of health in urban settings. This will imply the need to reorient research priorities and systems and to develop more participatory and transdisciplinary approaches that mobilize all relevant actors and sectors and that build upon all relevant knowledge systems. Finally, Europe should prioritize these global health challenges and this implies also strengthening cooperation with less developed countries in Africa.

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The role of Europe and of international science and technology cooperation

Specific needs for health research in low- and middle-income countries

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The challenges to health, equity and to social and economic development in low- and middle-income countries are manifold. Those for which research, science, technology and innovation can produce solutions are equally manifold. Yet, judging from the availability of international funds for health-related research for, in and with developing countries, it seems that international cooperation with low- and middle-income countries on health research, science and technology is of relevance only to a very limited set of conditions. The list is essentially limited to three: HIV/AIDS, tuberculosis and, more recently, malaria. And most of this research is done *for*, sometimes *with*, but rarely *by* researchers and research institutions in the countries in question. (IJsselmuiden and Kennedy, 2007). These three conditions are, of course, important – both to high-income and to low- and middle-income countries (LMICs) – but not to the exclusion of research and innovation for all the other conditions from which most people in LMICs suffer and die. There is, in fact, not a single LMIC where these three conditions jointly are responsible for the majority of morbidity and mortality. The relevance of this statement is that, on the one hand, many other research investments and efforts are needed in order to comprehensively address the health and equity challenges facing LMICs and that, on the other hand, the potential for research done in LMICs to be directly beneficial to the health or economic well-being of the sponsoring country is much greater than is generally assumed – given that we all face many similar problems but bring our own unique potential and creativity to the 'research table'.

In his eye-opening publication *"The Fortune at the Bottom of the Pyramid"*, C.K. Prahalad investigated the potential of commercial activity for eradicating extreme poverty and demonstrated that it is quite possible to make profits and contribute substantially to poverty eradication at the same time. (Prahalad, 2005). Perhaps even more important, those at the bottom of the pyramid – individually and collectively – gain self-esteem and confidence, both essential for long-term societal development. Prahalad provided in-depth analysis of many such ventures, many of which are essentially dependent on high-quality research and development (e.g. iodising salt for human consumption in India). Several of them were developed in and by specialists in low- and middle-income countries for use there but have become so successful that they have been exported to high-income countries (for example, the Aravind Eye Care System[1] and the Voxiva surveillance system which pioneered the use of mobile telephony for surveillance of communicable conditions and has now developed many other applications for governments and industry in high-income countries[2]).

[1] Aravind Eye Care System: http://www.aravind.org.
[2] Voxiva: www.voxiva.com.

Asking the right questions

When asking "what are the global challenges *[in health and quality of life]* and what role is there for Europe in international science and technology cooperation *[to address these challenges]?*", the focus is almost automatically on "problems" not on "systems". It is not surprising, therefore, that the Bill & Melinda Gates Foundation which pioneered international science cooperation to address "grand challenges in global health" is focusing entirely on products to deal with "conditions" or "diseases"[3] not on "research or science or innovation systems" in which low- and middle-income countries can become active players in identifying problems requiring scientific solutions and can become initiators of research or of research collaboration to find these solutions, let alone systems which will generate solutions that may turn out to be of benefit to long-term social and economic development and to the sponsoring high-income countries.

If the question is rephrased to "how can international science and technology collaboration be structured so that it advances health, equity and socio-economic development globally?", then the potential offered by the billions of people who do not yet contribute to global creativity and innovation comes far more sharply into focus. The mechanisms which can bring their creativity to global level comprise, in the first instance, helping to create national research, science and innovation systems that facilitate use of science and technology to address local (health) priorities and – in the process – enable researchers, research institutions and entire low- or middle-income countries to become contributors to global knowledge, health, wealth and fair distribution of all these. The first question – "what are the challenges and how can we help?" – limits Europe to its own capacity. The second – "how can science and technology collaboration improve global health/wealth?" – opens the door to the creativity of those currently living in or surrounded by conditions of ill health, poverty and under-development.

The subtitle of this paper "specific needs for health research in low- and middle-income countries" turns the question into one of aid and obliterates the view of "them" as potential contributors, originators and creators in spite of growing evidence that low- and middle-income countries, having attracted substantial investment in research capacity via commercial or scientific routes for many years, are now turning the table and are becoming leaders in areas where high-income countries have been uncontested until now. Brazil, China, South Korea, India, South Africa and other countries have shown that innovation can come from sustained and substantive research investment in LMICs. In the general commercial and industrial environment, the recent purchases by developing countries in the European motor manufacturing or heavy metal industries are well-known examples. In the health domain, there have been equally important developments in the pharmaceuticals industry, biotechnology and possible genetic manipulation. A group of middle-income countries sometimes labelled as "innovative developing countries" (IDCs) are investing heavily from their own resources in health-related research not only to solve their own health problems but also because investment in science and technology in the health sector can in itself be a source of socio-economic progress as it may lead to evidence-based decision-making, transparency and accountability, health equity and economic advancement. (Morel et al. 2005). This group of "innovative developing countries" includes South Africa, Brazil, India, China, Malaysia, Thailand, Mexico and others, but is now also attracting countries typically seen as low-income countries, including Nigeria and Uganda. The IDCs are rapidly overtaking high-

[3] *Grand Challenges in Global Health:* http://www.gcgh.org/Explorations/Pages/TopicsOverview.aspx.

income countries in terms of publications and patents in science and technology in particular, but probably also in the field of health.

From "health research" to "research for health" – from "vertical programming" to "responsible vertical programming"

If long-term sustainable [economic] development is the priority of low- and middle-income countries, dealing with high-impact diseases affecting these countries is the concern of research sponsors and collaborators in high-income countries interested in the "problems" of these countries. Clearly, there is a great need for disease-specific research to find new treatments that could eliminate particular conditions, reduce their occurrence or mitigate their consequences or impact. Based on the successes of smallpox eradication and (apparent) control of vaccine-preventable conditions such as poliomyelitis, it is easily forgotten that reduction and elimination of serious communicable conditions in Europe, such as tuberculosis, was a consequence of gradually increasing wealth – specifically in terms of nutrition and housing – rather than of discovery of new drugs or technologies. This, in turn, was based on a culture of, and substantial investment in, science, technology and innovation. Although with the available treatments low- and middle-income countries can now "leapfrog" some problems, the basis for sustainable health improvement remains the same as in high-income countries – by building sustained national systems for research, science and technology and innovation.

As a consequence, the terminology is changing. Whereas "medical" and "health" research starts with medical or health problems as the basis for description and analysis, "research for health" starts with the intended outcome. If "health" rather than understanding or product development is the core focus of the research, the enterprise is likely to become more multi-sectoral, integrative and aware of the need to measure the impact. **"Research for health"** is changing the direction of research as a societal effort towards specific societal values, namely health and health equity. The change is meaningful in the context of international science and technology cooperation with low- and middle-income countries, as it promotes finding common ground for collaboration, i.e. achievement of health. "Health research" focusing on specific health problems can lead to perceptions that "health research" in LMICs is substantially different from that in high-income countries given differences in the causes of morbidity and mortality. Even though this distinction is rapidly becoming unusable given the economic progress and consequent changing health patterns in many low- and middle-income countries, it continues to fuel the perception that research in high-income countries deals with different topics and cooperation with low- and middle-income countries may, therefore, not be relevant. A shift towards "research for health", however, will help to direct research, no matter where it is done, towards achieving health and finding the common ground needed to understand why cooperation between high- and low-/middle-income countries may be beneficial to both sides.

The way research is commissioned in Europe and North America leads, by and large, to the establishment of "topic-specific" research programmes. Using research excellence, as judged by publications and patents, as the key criterion, the bulk of international health research sponsors use competitive distribution methods to fund highly specific and narrowly targeted research projects. Often, there is no link with implementation, let alone with mechanisms to ensure that research is turned into innovation – into substantive changes in the way health care is being delivered or in health and health behaviour.

"Vertical programming" is the term used to describe this way of operationalising funding in health research in particular and in science and technology in general. Clearly, this way of funding research has had a great positive impact on health and well-being in Europe and North America and is continuing to deliver results. Nevertheless, vertical programming based on past research excellence not only makes it very difficult for low- and middle-income countries to enter this domain, but also delays harnessing their creative potential to the benefit of us all. Research and research sponsorship can also take forms that not only result in a product, treatment or understanding but also – at the same time – build up the capacity of low- and middle-income countries to use research, science and technology to become innovators. Vertical programming becomes **"responsible vertical programming" (RVP)** if the outcomes of research projects, programmes and investment leave a stronger national health research system *as well as* a product. This is the key to unlocking the global capacity for research and innovation, but it needs to be better understood.

International science and technology cooperation

European support, whether by the Community or by individual Member States, can serve many purposes. In simplistic terms, investment in international science and technology cooperation with low- and middle-income countries can be justified on three grounds – seemingly separate but with boundaries sufficiently blurred to make any distinction somewhat artificial.

International collaborative health research: a matter of self-interest

Firstly, if knowledge generation is the key intended outcome, then, from the point of view of the country or community sponsoring the research, there are many reasons for investing in international collaborative health research: (i) research opportunities are not available in high-income countries, for example for ethical reasons; (ii) research can be conducted better or quicker or cheaper in low- and middle-income countries; (iii) multi-centre studies or trials are needed in order to draw conclusions; for example, development of new drugs increasingly requires multi-centre trials as the margins of improvement in treatment have become ever smaller and even zero in "equivalence" trials; and (iv) because some conditions simply occur more frequently in low- and middle-income countries. For the first three reasons, the "self-interest" of the country or community sponsoring the research is perhaps the main reason why there is investment in such research. For example, the National Institutes of Health (NIH) is the world's largest agency for sponsoring and conducting research, with an annual budget of over $28 billion.[4] As a branch of the US Department of Health and Human Services, it focuses primarily on research to protect and improve the health of US citizens.[5] In spite of this, individual institutes and the Fogarty International Center are investing in research in low- and middle-income countries on the basis of its relevance to the USA. Even though it is extremely complex to know what proportion of total NIH expenditure is spent outside the USA,[6] let alone in developing countries specifically, it has been estimated that 1% to 1.5% of NIH research expenditure could be in the area of "global health". Viewed from another angle, this makes the NIH the single biggest non-commercial investor in health research in low- and middle-income countries outside the Bill & Melinda Gates Foundation.

[4] NIH appropriations: http://www.nih.gov/about/almanac/appropriations/index.htm.
[5] Mission of the National Institutes of Health: http://www.nih.gov/about/#mission.
[6] http://www.fic.nih.gov/programs/international/forum/2006/summary_nov2006.pdf.

International collaborative health research: a question of human rights, solidarity and development

"The American public wants to address global health disparities and believes that health research should be top priority for international spending".[7] There is no comprehensive information on collective bilateral or European Community spending on health research in low- and middle-income countries. With few exceptions, "health research" is not on the agenda of most European countries' development agencies and there is a dearth of civil society organisations/non-governmental organisations in this domain unlike in other areas of health action. By contrast, research involving low- and middle-income countries is largely funded by grants to universities and research institutes in high-income countries and is dependent on science and technology budgets rather than on aid or development budgets.
Yet "research", "science and technology" or "innovation" are crucial determinants of social and economic development and of health protection and improvement. Moreover, both are critically interlinked. Therefore, support for research to deal with global health problems is a key issue in global solidarity to reduce health inequities in and between countries. The lead given by the United States – public and foundation funding – needs to be matched by Europe and its institutions for the same reasons, i.e. the injustice of global health disparities in the face of our collective ability to address many of the underlying causes by means of action and research.

However, North America's generosity in funding research to address global health disparities has one serious limitation – it is, by and large, focused on finding "technical solutions" to "global priorities" and not on enabling low- and middle-income countries to identify and begin addressing their own health problems and health systems nor on assisting countries to strengthen their science and technology sectors in the process.

"Responsible vertical programming" may be one key component that needs to be added to international collaborative health research to optimise the benefits of such research for development in general.

Similarly, including research as a core component of the agendas of international development agencies is crucial to harnessing the creative potential of low- and middle-income countries – if for no other reason than to offer additional funding to that provided by science and technology budgets. While institutions awarding research grants may have severely limited mandates – such as funding on a competitive basis and on the basis of global excellence only – such funding could become more comprehensive and "system-building" if it were matched by relevant system development grants from aid or development agencies which have funding mandates that may include "capacity-building", training for research managers, establishing facilities or even improving financial control mechanisms. The "principle of complementarity" between research-sponsoring institutions and development agencies should be a major goal for all parties interested in optimising the potential of research for knowledge, health and health equity globally. As health-related research is often the only or the main investment in the science and technology environment in the lowest-income countries, simple "vertical programming" signifies a major opportunity lost!

[7] *International Health Activities Report. Global Health Matters 2007*; 5: 1-4: http://www.fic.nih.gov/news/publications/newsletters/ghmfeb2007.pdf.

International collaborative health research: a way of making friends

Health as a foreign policy tool, as a means to protect national security, to achieve trade objectives and to promote economic advancement of both high- and low-/middle-income countries, has been receiving explicit attention from politicians, scholars and educational institutions recently. (Ministers of Foreign Affairs, 2007; Kickbush et al., 2007). "Bioterrorism" and "avian flu" were the two major topics which brought health diplomacy to the fore, but the impact of this new development in health cooperation is likely to grow once the anticipated consequences of environmental changes on health become more visible. Although up until now "health research" has not been prominent in the health diplomacy debate, it is highly likely to become an area of interest. One only has to consider "avian flu" and other "emerging or re-emerging" communicable diseases to know that one crucial component of control of global epidemics of any kind is to strengthen epidemiological surveillance, laboratory capabilities, outbreak investigation and follow-up research in the countries where the underlying epidemic originates. Strengthening national research systems in LMICs is therefore a key to the national [health] security of high-income countries. However, national security is not only concerned with communicable conditions. For example, economic immigration is perceived as a key problem by many European countries. By reducing ill health in low- and middle-income countries and by contributing to economic activity by investing in science and technology [for health], problems related to economic migration may be addressed at the same time.

Beyond the immediate utility of health research to protect the health of high-income countries, supporting health research as a means to improve health is likely to lead to long-lasting relationships between individuals, institutions and countries that can weather dips in diplomatic relations. Investment in health research capability in low- and middle-income countries is an excellent way of supporting development and building long-term relations and will become a more explicit part of "health diplomacy" in future.

A specific role for the European Union in health-related science and technology cooperation in low- and middle-income countries

Investment by the European Union in health research involving collaboration with low- and middle-income countries is essential for the EU's own security, growth and science and technology prospects but also, and perhaps primarily so, from the perspective of achieving global health equity. This applies as much to the EU Member States as to collective European action. What then are the comparative advantages that funding by the European Union could have over bilateral or philanthropic funding?

Starting from the fact that research investments involving low- and middle-income countries need to be seen in context and, in particular, that the capabilities of these countries to conduct, commission, partner or use research to improve and protect the health of their citizens need to be increased in order to optimise the benefits of research for all stakeholders, including the European Union, the following list could constitute core characteristics of European funding:

1) ***Scale of funding*** – *in terms of both* ***magnitude and duration***. Research investment is, almost by definition, investment for the long term. Yet most agencies sponsoring research are tied by short-term political or institutional objectives. The European Union is in prime position to ensure long-term programming. Similarly, given that the EU is the sum of its parts, it should facilitate building large joint research programmes rather than provide

small-scale funding under "calls for proposals". In the context of international health research, consideration should be given to ***establishing an equivalent to the NIH's Fogarty International Center (NIH/FIC) to provide substance and give a voice to the need for long-term thinking in collaborative health research with low- and middle-income countries.*** Currently, there is no such facility anywhere within the EU's sphere of influence and the EU's ability to respond to "global health challenges" with research collaboration is severely limited as a result.

2) The EU can ***invest in research ventures that are too risky for commercial development***, and in the health sector there are many of them: from developing vaccines, drugs, diagnostics and technologies for both common and neglected conditions to creating the multi-disciplinary research excellence needed to deal with the social determinants of health – all require more support than is available from normal sources. (Commission on Social Determinants of Health, 2007). Health systems research, "implementation science"[8], equity-focused research and environmentally related health research are all beyond the interests of usual commercial research because of the uncertain outcomes. Yet each of these could develop into important tools, technologies and approaches that could benefit Europeans too. ***Investing in areas of research that receive no funding at present*** would be another way of saying this. Focusing on research needed to prevent premature morbidity and mortality from any condition in low- and middle-income countries, not just from the three major infectious conditions, could not only yield direct benefits for those in developing countries but also lead to better health technologies for Europe. Such areas include rehabilitation, disability, mental health, environmentally induced health problems or health system optimization.

3) ***Invest in research or science and technology or innovation system growth***. Good health research systems in low- and middle-income countries will make international cooperation on science and technology for health easier, quicker and better. If countries have in place appropriate legislation, priorities, regulatory mechanisms, ethical review committees and long-term plans for human resources and facilities development, collaboration in research could be far more productive than it often is at present. Therefore, one big challenge for EU investment in science and technology in collaboration with low- and middle-income countries is to ***fund system development as part of collaborative research and fund research into understanding how best to support such system-strengthening and how actually to implement "responsible vertical programming" or how to implement the 2005 Paris Agenda on Aid Effectiveness*** (OECD, 2005) – how to align with national priorities for health research and how to harmonise the aid given by the Member States.

4) ***Invest in ways allowing Europe to set and occupy the moral high ground*** – provide science and technology funding with a "difference". This is not merely based on human rights or social justice values but can also be part of the global health diplomacy that the EU should be developing. Perhaps the first and foremost part of "funding research with a difference" is to find ways to ensure that low- and middle-income countries remain in control of the research developments in their own country. Other aspects include promoting the principle of complementarity between the many funding stakeholders in health research; providing preferential grants to programmes that conscientiously work on understanding "capacity-building" better and acting on their findings; and applying a

[8] Implementation Science. Global Health Matters 2007; 5: 8. http://www.fic.nih.gov/news/publications/newsletters/ghmfeb2007.pdf.

"human rights" and "equity" lens to the way international research is funded. Research into "technology transfer" mechanisms could also make a meaningful contribution to helping to understand how science and technology cooperation can promote research creativity globally.

5) ***Support vibrant organised civil society/non-governmental involvement***, both locally (in European countries and in low- and middle-income countries) and internationally to provide technical support, engage in advocacy, support good governance and transparency and take on tasks not readily accepted by governmental or private-sector institutions. There are, in fact, excellent cases of substantive research for health being conducted by NGOs in low-income countries[9] that can set examples for high-income countries and other relevant partners for collaboration on health research. In addition, supporting establishment of networks of excellence between researchers in the "north" and "south" will be another meaningful contribution to global exchanges and collaboration on science and technology.

6) ***Invest in research needed to obtain and maintain a good understanding of international spending on research for health, provide analyses and set the directions for the future***. There is currently very little evidence available and few, if any, sources of financial support to start such efforts. One such effort is the ***Health Research Web***,[10] which has started to organise and understand international research cooperation on health from the perspective of the "host country". Once fully developed, such facilities will also make it much easier for European researchers to find appropriate colleagues and institutions in low- and middle-income countries and to track progress towards health goals.

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[9] For example, Centre for Science and Environment in India: http://www.cseindia.org/.
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Energy sustainability and climate change

Global energy resource supply - key research needs

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Introduction

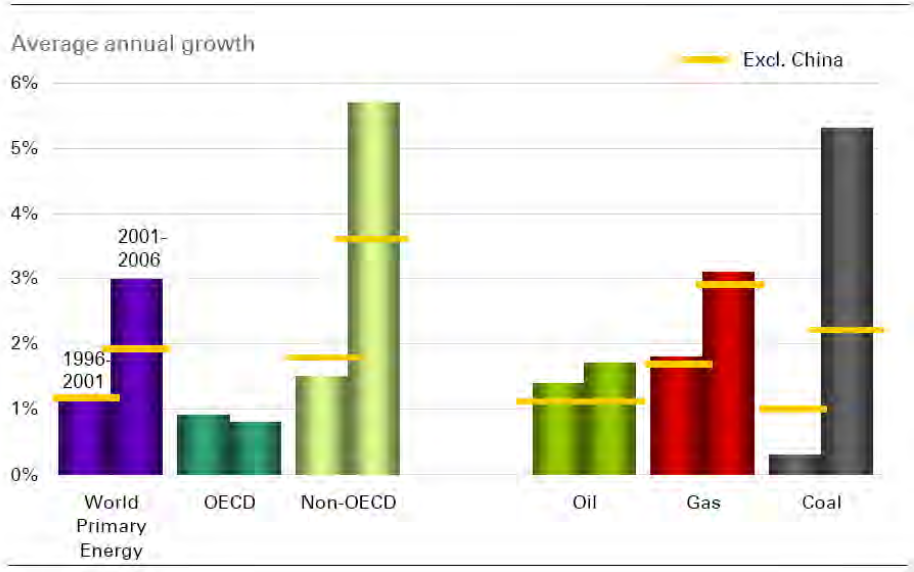
Global energy supply is amongst the major global challenges for future research due to a mixture of economic and political developments. The largest part of world energy consumption are fossil fuels (oil, gas, coal), and the process to change the energy mix in favour of renewables like solar or wind energy is rather slow or very limited, while the future use of nuclear power is subject to fierce debates which not only relate to sustainable use or import independence but mainly to risks of proliferation in instable world regions. There is a rapidly growing need for more international research on future energy supply, energy efficiency, and the international linkages between economic development, energy use and sustainability, a triad of goals established in 2006 by the EU's greenbook on energy. This need relates to the investment in and trade of energy, the restructuring and sustainability of energy mixes, and last but not least, the embedding of scientific R&D progress into the political processes around energy supply, be it in climate change policy, national energy security policy, or the geopolitics around energy supply and demand in a world of rapidly increasing political importance of energy relations.

1) Trends and economics of energy supply from different sources

The supply of energy has always been characterised by regional concentration of energy source abundance, like traditional biomass, or fossil fuels like oil, gas or coal, or renewable energy like wind, water or solar energy. This has led during the last century to regional specialisation in energy supply, and for most energy resources the regional bias prevails. The global implications of energy supply can be easily attached to oil as the only energy input that has been traded around the globe for over half a century and with markets that set one global price for oil. Nevertheless, due to a number of developments during the last years, all major energy source supplies have become subject to a number of new constraints and challenges.

After the end of the cold war in the late 1980s fundamental economic changes have taken place, mainly in the former communist countries – amongst them energy-rich Russia – and in a number of emerging economies, which depend on energy imports, led by China and India. Economic growth has caught up and is being maintained at a high rate (e.g. 8 to 10% for China during the last 5 years). The shift in international economic activity includes a more than proportional shift in energy demand, as the emerging and transitional economies not have succeeded in decoupling economic growth from growth in energy consumption. Chart 1 shows how growth in energy demand and the regional demand patterns have developed during the last ten years, differentiated by the five-year-periods 1996 to 2001, and 2001 to 2006 (BP Statistical Review 2007).

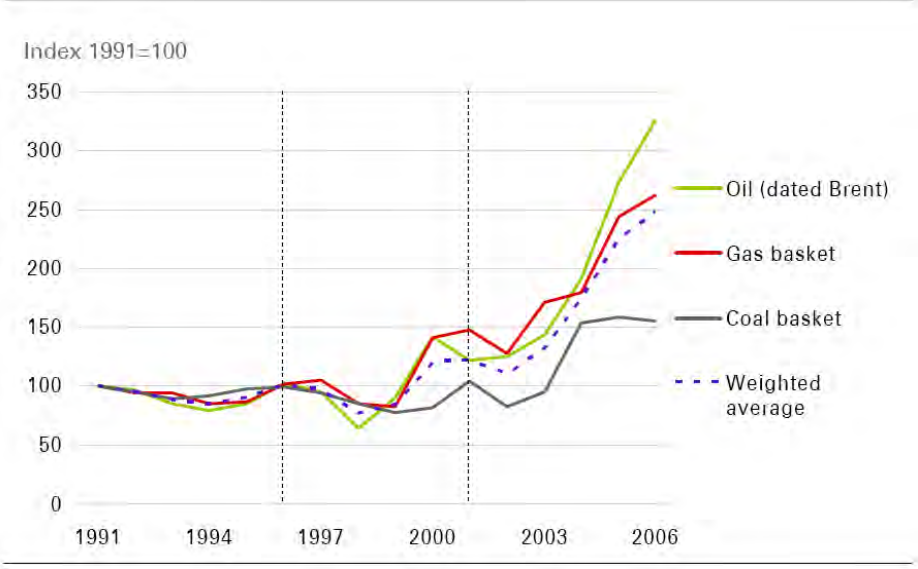
Chart 1: World Energy Consumption Growth



Source: BP Statistical Review 2007

At the same time, the supply of conventional energy, especially oil, has not kept pace with the demand dynamics. Accordingly, the price for oil has risen sharply in recent years, influencing a number of supply- and demand-side factors: investment and diversification, substitution between energy sources, and incentives to increase the efficiency and independence in energy consumption of many countries, including the members of the European Union. The trend of the oil price applies to all major fossil fuels (see Chart 2).

Chart 2: Prices for fossil energy sources, 1991 = 100



Source: BP Statistical Review 2007

The regional scope of energy markets differs. Thus, they need to be illustrated separately.

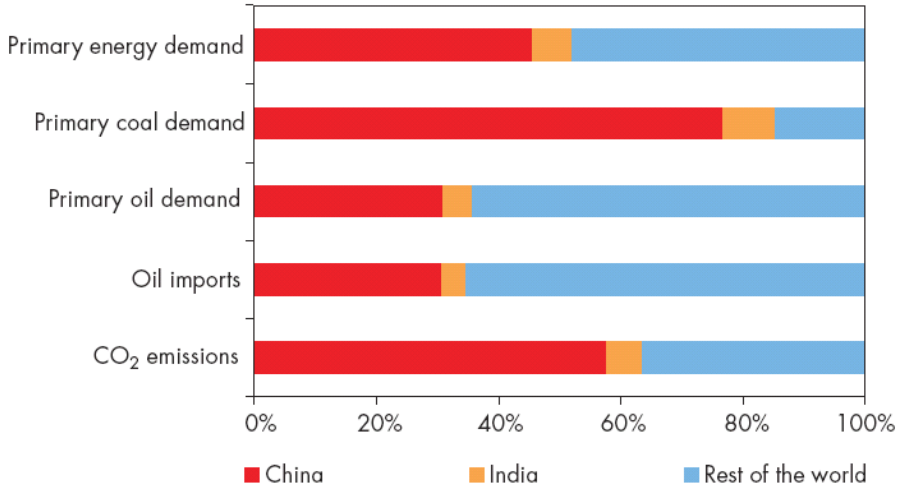
First – and as mentioned – the *oil* market is driven at the international level and oil supply has experienced a number of developments that contribute to the recent hike in prices. The market is

international, but it is not free of market distortions. Only a few suppliers exist, with the OPEC as a cartel in full operation. In OPEC countries (e.g. Saudi-Arabia, Venezuela) suppliers are state-owned firms and thus, oil production is government-led. Beyond the OPEC, global oil production is decreasing, e.g. in Norway or UK (North Sea) due to shrinking reservoirs. This implies a future shift towards a more state-controlled oil market, with full consequences for oil prices to rise further in order to guarantee high profits, unless investment in new drilling capacities is increased. However, profits can be kept high by lagging investment in new capacity as well as in transport infrastructure. On the other hand, the hike in prices has given rise to international investment in alternative sources, including previously non-profitable conventional sources (oil from tar sands in Canada, coal to liquid in China), but also in alternative energy from renewable sources like wind and solar, or in higher energy efficiency in consumption (EU).

Second, *gas* supply shows different market structures compared to oil, there is no global market and this will not change in the foreseeable future, as most of the gas supplies are traded either by pipelines or by ship, after transition into LNG (liquefied natural gas). Both modes of transportation demand large-scale investment. In the Northern and Central part of Europe, gas is delivered through pipelines to most EU countries, mainly from Russia; while in Southern Europe member states receive LNG from Algeria. In North America, LNG dominates, the same holds for Asia. Thus, gas supply is for the coming years rather a regional issue than an international one. Nevertheless, there are reasons why gas supply is increasingly becoming an international matter. In many countries, amongst them most EU member states, long-term gas contracts include a pricing rule that links the gas price to the oil price, as many large consumer countries have introduced gas price indexing in the 1960s already). Thus, gas markets mirror the cartel problem of the oil market. Moreover, the share of gas in the energy mix is rising, new explorations and infrastructures are in a planning state (Nabucco and North Stream pipelines) and this brings about political challenges for the EU and in dealing with new supply partners, amongst them potentially Iran and Casachstan.

Third, *coal* – the major fossil energy input for fast growing China, but also for a number of EU member states (e.g. Germany, Poland), is on the rise again, while having been traded globally for many years. As coal can be found in many regions and countries, there is so far not a problem of market power and state-owned suppliers at the global level, while the fight against further increase in GHG emissions is closely connected to the combustion of coal for energy production (see chart 1), and to the national decisions on using the domestic coal reserves. The high oil price makes it profitable to even convert coal into fuels (coal to liquid – CTL) which is a process with high carbon emissions and efficiency losses. The major challenge for research on coal lies with carbon capture and sequestration (CCS), which is being investigated in a number of industrial countries (US, Norway) and which clearly is the only climate-friendly option for using coal in the future. CCS is not only a challenge for the technological research, but also in terms of implementation. The installation of pipelines and storage, but also the liability for the security of these new installations (leakage of CO2) puts high demands on policies that support CCS.

Chart 3: China's Demand for Energy

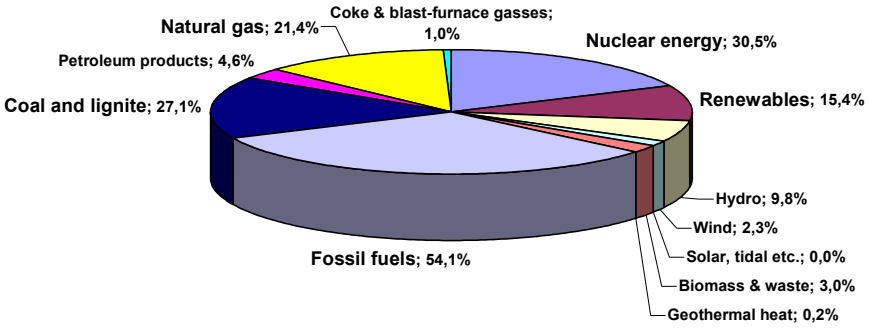


* Based on preliminary estimates for 2006.

Source: WEO 2007

Fourth, for energy supply from *renewable* sources, markets are mainly regional in their scope due to the small scale of production, especially from power from wind and solar sources, and the lack grid infrastructure. Only hydropower can be regarded as a well integrated source of electricity. For fuels made from energy plants ("biofuels"), more trade flows can be expected in the future (e.g. between the EU and Brazil). Moreover, renewables are not only among the major means to reduce GHG from energy production, but are part of the EU's diversification strategy to lower import dependency. For a better EU market integration of electricity production the grid infrastructure is evolving only slowly and at a regional level. Regional concentration of availability of sun, wind and water and the lack of storage of electric power add to the relevance of capacity of infrastructures and free market access for a future increase of renewables in the energy mix. These issues will evolve in all parts of the world where high or rising energy demand is supposed to be met by renewables. Also, due to the global dimension of climate change and the large contribution of energy production to emissions, the supply of low carbon energy is a global challenge, and this has global implications for ambitious R&D policies in this field.

Chart 4: EU-27 electricity mix in 2005 by fuel type



Source: Eurostat 2007

Energy supply is a global challenge already today, as there are at least three goals attached to it : security of supply, economic efficiency, and sustainable energy production (see also Haug 2008 in this volume). Although not for all of the energy sources there is a need for global research and development cooperation today, this could become an issue in the foreseeable future. There are four outstanding points that need attention:

1) *Markets*: there is a tendency to monopolise supply of oil and gas further, given a high level of already distorted markets, mainly by nationalisation of oil and gas firms. This trend applies to regions where there is clearly a lack of democracy. This is a challenge for economic and foreign policy makers.
2) *Technological change and restructuring of energy supply*: all major energy consumers face the three challenges which are named as EU goals above. Even countries with abundant energy resources are confronted with climate change and the need for GHG mitigation and domestic security of supply. This can only be addressed by integration of energy-related climate strategies and the regional energy supply strategies.
3) *Critical energy sources* (renewables, coal, nuclear): New technologies and improvement of existing ones are needed to a) make renewables more competitive, b) decarbonise coal by carbon capture and sequestration (CCS), c) increase efficiency in using oil and gas for all modes, and last but not least d) address the full range of issues relating to nuclear energy.
4) *Trade and investment*: the transportation of energy will be growing dynamically. This implies increasing demand for infrastructure improvement, for all primary energy sources, and for electricity. Innovations in energy trade technologies (grids, pipelines) and in management of energy transport are vital for the future global supply situation. Even if there is agreement on how future S&T for energy supply should look like, the dimension of the needed investments is huge and the political will to fully engage in this is critical.

2) The European Union's Position and Role

The EU is among the large energy consumers worldwide with a share of world primary energy demand in 2005 of 16% (WEO 2007: 109; based on table 1.14). The EU faces basically two challenges. One is the internal dimension of energy supply which relates to the implementation of an internal energy market, similar to the internal market for goods and services, the free movement of capital and labour. The other is the external dimension of energy supply, including trade relations, R&D cooperation and technological transfer as well as the foreign policy relations with other consumer countries and with producer countries. As pointed out by Haug (2008) there are already widespread activities in R&D cooperation at various governance levels, nevertheless, the extent of funding and of pushing S&T cooperation beyond the EU will need to increase.

Energy imports and external policy challenges

The energy consumption of the EU as a share in overall worldwide energy consumption is shrinking and will continue to do so under various growth scenarios (WEO 2007). Still, Europe is a net importer of energy sources and this will remain unchanged in the foreseeable future, even with an increase in renewables from domestic sources.
As stated in the Communication of the European Commission (2007) "An energy policy for Europe", import dependency for fossil fuels will increase from a current average of 50% for all EU members to 66% in 2030. For gas imports, this dependency is expected to rise from 57 to 84% and for oil from 82 to 93% by 2030.
The external dimension of this rising dependency lies with the trade-offs and the synergies between the security of supply and the reduction of GHG emissions. In order to cooperate with other consumer and producer countries, the EU needs to set up not only S&T projects, but also its own political strategy as one single actor, instead of uncoordinated negotiations of 27 national actors.
The cooperation between the EU and other countries could address amongst other issues:

- How can the EU prepare in a more effective way to address security of supply and climate change mitigation in a cooperative way with other countries, both consumer and producer countries?
- What can be learned from other consumer countries' energy strategies?
- Which countries focus on technological research in a similar way (e.g. on CCS) and is there scope for merging the activities?
- How should a low-carbon energy strategy be embedded in international actions on, inter alia, climate change, non-proliferation, trade relations?
- How to facilitate and implement innovations in using renewables and conventional energy sources in places where they are most efficient and climate-effective?
- How does future global energy supply depend on timing and dimension of investment, access to markets and climate goals and how could this be coordinated?
- Is there a need for a global institutional setup for energy policy making and if so, how should it be constructed?

The EU's energy and climate strategy

The EU's energy and climate package from the March 2007 summit was a clear signal to the rest of the world that the EU does not regard energy policy as a separate issue from climate

matters in its policy framing. Still, it has to be kept in mind that decisions about investment into capacity and infrastructure, new technologies, and supply capacity are made by the companies within and outside the EU. Guidance and reliability of political framing for business in this sector comes from two EU policies and this framing affects the international markets in the mid-to long-term, too. First, the EU is driving forward the completion of the internal energy market. This will lead to more competition and at the same time to a consolidation of energy suppliers through mergers and acquisitions. Second, the EU's emissions trading scheme applies to a large extent to the energy sector or to energy-intenxive industries. The scheme, especially after full introduction of auctioning of emission rights after 2012, sets strong incentives for more investment into energy efficiency and new low carbon energy technologies. Nevertheless, the horizon for energy investments is far beyond the one currently foreseen by the ETS (2020). An optimisation of investment in new technmologies will not go without massive increase in research funding. Either way, the effect that the climate policy in Europe will lead to energy supply at higher carbon efficiency feeds back into international energy supply. If this drives down EU demand, demand pressure will decline - although reduced demand in the EU will not compensate for the massive increase in Asia. If climate policy with carbon pricing creates new technologies, the EU's export potential will be improved and help to drive export-led growth.

For the integrated EU strategy, and in order to address both the security of supply and the reduction of GHG emissions, the EU faces in its external policy strategy an important field for which it is not well prepared yet. The current implementation of the Lisbon treaty will widen the common external policy and energy policy has been high at the agenda of EU foreign policy (Javier Solana demanded to "speak with one voice" already in 2006). Energy and climate S&T strategies thus need to be part of the new external policy strategy of the EU.

3) Research cooperation beyond the EU

3.1 Energy supply as a field for multidisciplinary research

For research on future energy demand and supply, a number of disciplines need to get involved. Energy research has always been subject to various research disciplines. Intensifying combined analyses of economic, engineering, and political sciences for instance and bringing this to a level where major consumer countries interact, should be part of an EU strategy to address the challenges in this field. However, also between major consumer and producer countries there is a potential for more cooperation based on multidisciplinary approaches. The subjects of multidisciplinary cooperation include a) technological progress in energy production from coal and its implementation, b) technological progress in energy production from renewables and its implementation. c) Scenarios of future energy supply given the constraints from EU goals (competitive, sustainable, secure). d) Economic, political, legal evaluation of energy options under various international policy settings, including a global market for carbon, clean coal technology transfer, phase out of fossil fuels, improved energy efficiency. e) New technologies in and the future need for transportation infrastructures and their management. f) Institutional and legal aspects of implementing changes in energy supply at the national and international level.

3.2 The role of international research teams

International research teams driven by an international problem could help to identify and reduce gaps by comparing national or regional research methodologies or research organisation. E.g. gaps in internationally comparable data availability can be identified and exchange of information has the potential to be part of the solution to this. This also helps

promoting a dialogue on energy supply that is driven by facts or ideas rather than competition or free riding. Re-thinking the biases from existing international energy institutions (OECD – Non-OECD) would most certainly be part of the prerequisites of international research cooperation on energy. The downsides of this comprise a larger scale of management and bureaucracy in order to match all needs of national teams and the donators. The legal aspect of who is entitled to use research results, especially those which generate new technologies with high market potential, needs early settlement and a legal reference at the international level.

3.3 Good practice in knowledge and technology sharing

The practice for sharing the knowledge and the products evolving from cooperation is a matter of the legal framing and implementation of rules at both national and international level, closely related to funding structures and the overall goal of the cooperation (e.g. if technology transfer is part of the goal, then funding structures do not necessarily pre-empt the future benefit sharing). This is a matter of both building confidence and using the "right" legal institutions. Framing should be given by policy fields, e.g. global climate policy. Here, good practice includes reconciliation of interests between industrialised and emerging economies. This, certainly, depends on global agreement in this field. It also includes the option that research cooperation channels financial transfers from the EU for bringing innovation to developing countries, and this being a sensitive issue for EU member states.

3.4 The potential interest of partner countries in an intensified S&T cooperation

Cooperation in innovating energy supply needs to separate consumer from producer countries. Other consumer countries, as diverse as the OECD members and the emerging economies China and India, are facing the same global challenges as the EU: rising fuel prices and climate change. They differ, though, with respect to defining the problem. Energy supply is a crucial national interest, to most countries a matter of national security in the very meaning of the word. Climate change is seen by emerging and developing countries as caused by the industrial world. Finding research partners with the same interests, namely increasing energy efficiency with state of the art technological equipment, innovation of energy systems at home, diversification of supply, is an easy task and the many initiatives that exist already can be taken as a proof for this (see Haug 2008 on the post-Rio initiatives on clean energy technologies). Setting up a broader schedule among energy consuming countries will depend on the flexibility of international organisations. As long as the IEA only represents the OECD consumers, the EU will need to come up with separate initiatives to include China and India. The global climate policy process will thus be important. In this context the EU will need to deliver on the one hand, GHG mitigation at home and on the other hand, will have to deliver technological and financial assistance to the developing countries, including the emerging economies. As China and India are facing severe constraints for their economic growth if they continue producing with over proportional energy-intensity, their interest in cooperation on energy supply from efficient and renewable sources is high. The same argument holds for the United States. As the US currently lags behind the climate debate and the technological development of clean energy, their major interest will lie in catching up, but also in taking the lead in low-carbon energy research and innovation.

A more difficult task is to incentivise the participation in clean coal S&T cooperation for developing countries. As these countries will not engage in global emission reductions in the same manner as the EU does, they do not have incentives to install coal fired power plants that loose 10% in efficiency due to CCS. Yet, as this technology is still infant and as there are various parts to do research on (e.g. permanent sequestration; transport and infrastructure; legal aspects), a partial engagement between the EU and China beyond the current state is

very desirable also for China. China will have to rely on coal and on foreign technology for the next decades. Combining these needs by making EU technological cooperation on coal use depending on CCS application on Chinese territory would at least set a clear guideline for future S&T cooperation in coal combustion.

Another difficult task for cooperation relates to major producers like Russia or the OPEC member countries. Single countries are interested in energy efficiency or renewables research. Nevertheless, the intertwinning of political interest and energy supply makes it difficult to approach countries like Iran, Irak, Venezuela. Cooperation in the traditional fusion energy research goes along with fears about nuclear proliferation. Clearly, countries like Iran would have an interest in more cooperation in this field, but this is not an option for the EU given the lack of democracy in Iran and other OPEC member countries. For Russia, research cooperation on more efficiency in energy supply is valuable as Russia will not continue to keep pace with demand for gas and oil and wants to reduce domestic consumption in order to keep up the exports.

4) Summary

In order to address the current and upcoming challenges in energy supply, the EU should act as a driver for an international scientific platform for energy research among consumer and producer countries. This demands for a strategy going beyond the current institutional framing given by the OECD group of consumer countries. While research cooperation with the US may be a win-win constellation in terms of insight and outcome, cooperation with large suppliers (Russia, Saudi-Arabia) and with emerging consumers (China, India) are challenging and would thus need to start buy building capacity, before tackling the specific challenges. A first step in this direction is urgently needed for the low-carbon energy technologies. Capacity building should include better access to information both in terms of exchange of data and of creating information – issues that matter for all potential cooperation partners. The EU as a global frontrunner in climate protection and in restructuring its energy system can offer collaboration in climate-related energy research going into this direction, but most of all it could provide the financial resources that are currently not living up to the challenge.
Within the EU there needs to be the expression of political consensus on the nature of a S&T cooperation in energy policy. This is needed especially to strengthen the external EU policy in this field.

The structure of the research strategy could be defined along four themes: markets, technological change and restructuring, critical energy sources, trade and investment. Among the issues to be addressed are: effective ways to address security of supply and climate change mitigation; learning from other consumer countries' energy strategies; finding scope for merging national activities; embedding national low-carbon energy strategies in international actions on climate change, non-proliferation, and trade relations.

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Haug, M., 2008, Global research on energy: new objectives, new instruments and a paradigm shift

Global research on energy: new objectives, new instruments and a paradigm shift

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International cooperation on energy science and technology is alive and well, thriving and expanding.

Political announcements like the G8-Gleneagles Plan of Action of July 2005 call for expansion of international energy research cooperation and recommends to

"*raise the profile of existing networks and to encourage broader participation where appropriate; and … seek ways to improve the current arrangements for collaboration between developed and developing countries.*"

Announcements of yet another bilateral or international energy research agreement, of yet another public/private partnership, international conference or networking event to enhance international cooperation in sustainable energy technology or energy policy research have become weekly fare.

This paper will take stock of the historical development of international energy S&T cooperation approaches. It will highlight the changing objectives of energy research. It will focus on the changing role of international energy S&T collaboration due to the climate change debate, and will attempt to formulate options for future actions for Europe.

1) Global energy research priorities in the 21st century: changing priorities

Energy policy traditionally focused on the 3 E's – energy security, economic competitiveness and environmental concerns. These objectives determined national and international energy technology and policy research. In recent years, it has become obvious that a broader approach is needed to address the global energy sustainability and climate change challenges. The global energy research priorities of the 21st century go beyond the 3 E's. We need to

- invent, develop and diffuse clean, climate friendly and affordable energy generation and conservation technologies;
- help societies to transform their energy use and adopt clean and sustainable climate energy systems; and
- ensure "access to energy for all", particularly in developing countries to meet the Millennium Development Goals by 2015 and beyond.

2) Taking stock: The track record to date

International S&T collaboration in energy has a long tradition. For decades such cooperation focused exclusively on basic research, innovation, development and diffusion of energy technologies. In contrast, international cooperation in energy policy research is of recent vintage. As policy decision makers became aware that they needed internationally validated,

socio-economic research on liberalization of energy markets, sustainability and climate change issues, international energy policy research emerged as a growing field.

International S&T collaboration in energy has taken the classic forms of

- **governments or the European Union engaging other governments, academia, private enterprises, international organizations and NGOs**. Such engagement involves either bilateral or multilateral agreements, contracts, public/private partnerships or voluntary agreements. Most European governments have dozens of bilateral international energy S&T agreements and are party to many multilateral agreements. The US alone has signed more than 150 bilateral energy S&T agreements.
- **universities, research institutions and individual researchers partnering with counterparts in other countries on a bilateral or multilateral basis or with the private sector.** The bilateral arrangements of the Helmholtz Gesellschaft with research institutes in China or Russia; or the BP financing of the Energy BioSciences Institute in partnership with the University of California, the University of Illinois and Lawrence Berkeley National Laboratories in California are typical examples.
- **international S&T collaboration sponsored and sometimes financed by international institutions** such as the UN organizations, IEA, OECD, GEF, the World Bank etc.
- networks created by non-government institutions , associations and civil society at large to address national and global energy issues.

The dynamics of international S&T collaboration programmes, the choice of objectives, decision making during implementation and ultimate effectiveness are highly influenced by the selected financing, cost- or task-sharing arrangements. Many variations exist from independent financing for each participant to pooling of resources for specific projects, to 100% contract financing of entire research programmes.

The benefits of international S&T cooperation in the energy field are well-known, documented and often repeated (Gallagher/Holdren, 2004; IEA, 2007). The most important are

- capacity building by the participants to carry out research faster and better;
- gaining access to diverse R&D capabilities, facilities ,expertise and a wider and deeper pool of manpower;
- testing technologies under diverse conditions and for different markets
- sharing costs of pre-competitive R&D;
- working with a limited number of cutting edge researchers on “big, indivisible science “ problems;
- reducing costs of emerging technologies through accelerated learning;
- creating common technology pathways, policy solutions, learning investments and standards to limit the risks of market introduction of new technologies;
- establishing common testing, performance and safety standards and labelling;
- information-sharing, education and training;
- working with multiple countries to address global issues;
- sharing and analyzing best practices in energy policy research; or
- creating consensus for technology and policy solutions, broadening markets and public acceptance.

The costs or drawbacks of international S&T collaboration in energy are equally known, but less discussed and documented (Justus/Philibert, 2005). The major problems that deter participants or lead to ineffective programmes are:

- concerns about Intellectual Property Rights and possible loss of prior competitive advantage;
- administrative and personnel costs of reaching agreements, and then administrating the agreements are non-negligible, time-consuming and often detract from productive work;
- vested interests can influence research design, analyses and choices so that new or disruptive technologies or policies are not adequately considered or overlooked;
- group thinking, "herd behaviour" and emphasis on consensus can miss promising new technologies or pathways;
- international S&T cooperation agreements are often the results of political announcements without shared objectives or commitment by the institutions and people who will ultimately have to implement the agreements;
- "free-riders" that do not contribute or live up to initial commitments can undermine international S&T cooperation.

The long list of costs and benefits of past and existing international S&T collaborations in energy underscores that collaborative activities in this field require careful attention to design and implementation. "Added value", mutual benefits can only be expected if the participants share the same or compatible objectives, agree on each others' contribution and manage the S&T activities with the risks in mind. Objectives and focus may vary widely:

- First, an increasing number of international technology collaboration programmes go beyond pre-competitive research; they do not stop at the "technology pull" phase, but are designed to deal with the demonstration and market deployment of a given technology or policy instrument.
- Second, many countries and programmes attempt to combine development aid, advancement of trade and commercial interests, transfer of technology and export promotion with international S&T collaboration. Prima facie, the combination of objectives mobilizes additional funds and contributes to information sharing, tackling of the Millennium Development Goals, reduction of GHG emissions and modernization towards a more carbon friendly energy system. However, participants are very sensitive to these non-research objectives of international energy collaboration as they often undermine effective design of the research effort.
- Third, S&T diplomacy has become an important foreign policy objective. Actions on global issues such as sustainable energy and climate change require preparatory processes and consensus that can be built through S&T collaboration.

3) Existing instruments and mechanisms for international energy S & T collaboration

The development of institutions, mechanisms and instruments for international S&T collaboration on energy has gone through three major phases

- the development of cooperative global nuclear research in the aftermath of Eisenhower's " Atoms for Peace" speech in 1953;
- the development of " energy diversification" strategies following the oil crises of the seventies and eighties; and

- the emergence of new international energy S&T cooperation approaches and participants post-Rio and post- Johannesburg in the past decade.

What can we learn from their development, how effective are they and where are important gaps to deal with the global energy research issues of today?

Global nuclear research cooperation has been developed through the creation of a host of new international institutions, bodies or research institutes: CERN (European Center of Nuclear Research) started in 1954 and includes today 20 European members, 8 observer states or bodies, 37 non-members and maintains a wide network of international cooperation with non-European universities and research institutes. EURATOM and the International Atomic Energy Agency (IAEA) were created in 1957. ENEA, now NEA/OECD (Nuclear Energy Agency) was created in 1958 to *"assist its Member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for the safe, environmentally friendly and economical use of nuclear energy for peaceful purposes."* Industry and governments undertook the subsequent commercialization and rapid diffusion of nuclear energy; first, in many OECD countries and the USSR, and then worldwide. The virtual stop of nuclear energy expansion in the OECD countries following the Chernobyl and Three Miles Island incidents slowed resources for nuclear energy research, but the international research institutions, bi-lateral and multi-lateral instruments and mechanisms in the nuclear energy field continue to function effectively.

To meet the global energy challenges of the 21st century and support the "renaissance of nuclear energy", particularly in emerging economies, new mechanisms of international collaboration have been put in place since 2000 with a wider set of participants: First, international collaboration in nuclear research has been extended to emerging economies and developing countries under existing or new bilateral and multilateral mechanism and instruments. The EdF-led NULIFE Network of Excellence including Russia is one example. Second, the US initiated in 2000 the Generation IV International Forum (GIF) that includes at present 9 countries (Argentina, Brazil, Canada, EURATOM, France, Korea, South Africa, Switzerland, UK and the US). Third, in 2006, the US sponsored the Global Nuclear Energy Partnership (GNEP). This partnership includes 21 countries of which 7 European (France, Italy, Poland, Romania, Bulgaria, Slovenia and the UK) and industrial companies. Fourth, within Europe, the European Technological Platform on Sustainable Fission, a high-level industry group is being established and complements EURATOM and the bilateral international nuclear activities of EU member countries.

Fusion energy research has been the model and success story for international S&T collaboration during the past decades: The first IAEA fusion energy conference in the USSR took place in 1968 and bilateral agreements between the EURATOM, the US, Japan and the USSR (and their respective research institutes) followed. International cooperation continued and continues in the framework of the IEA Fusion Power Coordinating Committee, the IEA Implementing Agreements, and the IAEA Fusion Research Council. In 1985, the ITER project was conceived and brought together EURATOM, Japan, the US and the USSR. In 2006, the most ambitious international energy S&T cooperation, the ITER Organization was established by EURATOM, Japan, USSR, China, Korea, India and the US. The ITER Organization will be supplemented in the future by an agreement between EURATOM and Japan to cover the **I**nternational **F**usion **M**aterials **I**rradiation **F**acility (IFMIF) and bilateral agreements with the USA, Russia, Korea and others.

To date, EURATOM takes the lead on international fusion collaboration. The model works well because fusion development is still in the basic science/pre-competitive research stage. As fusion energy approaches commercialisation and industry is not only a mere supplier of equipment, the question of IPR will become increasingly important.

The EU - through EURATOM, its Member Countries, institutes and industries- is well positioned to use the existing instruments and accelerate international collaboration. However, the fact that EU policy does not mandate a EU wide nuclear energy policy, and not all EU Members are likely to pursue a nuclear energy strategy impacts on future mechanisms and instruments for international S&T collaboration in the nuclear energy field. Naturally, new, additional mechanisms and instruments need to emerge so that those countries selecting the nuclear energy option can get optimal benefits from international S&T collaboration in this field.

In the aftermath of the oil crises of the seventies a number of non-nuclear institutions, instruments and mechanisms were created to foster international energy technology cooperation. The main objectives were to diversify energy sources away from oil and encourage energy efficiency. Many of these international collaborative research projects did not survive the decline of oil prices by the end of the eighties. But a few important institutions and programmes flourished and built strong international ties among a generation of energy S&T researchers. These are

- bilateral R&D programmes for non-nuclear energy technology collaboration between the major industrial countries and their research institutes and universities; and
- the International Energy Agency (IEA) collaborative R,D&D programmes and networks. The IEA initiated 57 international S&T cooperations, so called Implementing Agreements, in the 70s and 80s to enable researchers of IEA member countries to develop jointly technologies for cleaner coal, hydrogen, energy conservation and fusion. These international R,D&D cooperation treaties were supplemented by governmental, permanent Working Parties or Coordinating Committees on fossil fuel, fusion and energy end-use technologies to allow regular information exchanges and development of new initiatives.

EU countries and the European Community bodies participated actively in these international S&T efforts. They were mostly public sector led international research efforts and reflected the energy mix of member countries and energy security and diversification priorities of the time.

The post-Rio period in the nineties and the Johannesburg 2002 World Summit on Sustainable Development revived and refocused international S&T cooperation on energy. Recognizing both the need for carbon neutral technologies and policy research to deal with the environmental and climate change challenges and the importance of delivering energy to the poor in developing countries, new instruments and mechanisms for energy collaboration were created und the traditional bi-lateral agreements among Governments, academia and the research establishments expanded. For Europe, the focus of energy research was reoriented to " clean technologies" and in the area of international collaboration to "cutting edge" countries like Japan and the US, emerging countries like China, Russia, India or Brazil and neighbouring countries To name just a few of the new or expanded instruments:[1]

[1] The important contribution to intra-European energy technology cooperation through the EU Framework Programmes and the ERA-Net initiative needs to be acknowledged. However, this is not the focus of this paper.

- **the UNFCCC** and its Subsidiary Body for Scientific and Technology Advice (SBSTA) provided a new platform for research collaboration among countries and linked science and technology with climate policy and public awareness. The IPCC supplemented the emerging international collaboration under the UNFCCC umbrella through their Assessment Reports, and Special Reports on "Technology Transfer" and "Carbon Dioxide Capture and Storage" (IPCC, 2000 and 2005).
- **International organizations such as the UNDP, GEF, UNEP, World Bank etc** more than tripled their funding for carbon neutral technology transfer to developing countries and related energy policy research.
- **The EU 6th Framework** opened the European Research Area to the world with substantial international cooperation (INCO) activities. Both the "Sustainable Energy Systems" with and the "Environment" Programmes funded international research and training activities for renewables and other climate friendly technologies, in specific countries or regions outside Europe, including one INCO-ERA-Net, the SEE-ERA-Net.
- **The International Energy Agency (IEA)** refocused and enlarged its international technology collaboration network three times during this period to address new global challenges.
    - First, in the nineties, the IEA added a Working Party for Renewables Energy Technologies and Implementing Agreements for Photovoltaic, Concentrated Solar Power, Bioenergy, Wind, Hydro and Geothermal Energy. New Implementing Agreements on Greenhouse Gas R&D, Hybrid and Electric Cars, Energy Technology Data Exchanges, Energy Technology Policy Modelling and Demand Side Management followed.
    - Second, in the context of the 1995 UNFCCC conference 23 IEA/OECD members and the EU created a special Climate Technology Initiative (CTI) to address S&T collaboration with and technology transfer to developing countries.
    - Third, in 2003 the IEA opened its Implementing Agreements to all countries world wide, to industry and civil society institutions. The Agency established new Implementing Agreements on Renewable Technology Deployment, on power network optimization, and recently created a Network of Expertise in Energy Technology (NEET)

At present, there are 41 agreements with several thousand participants from 59 countries, research organizations or companies (IEA, 2007).

- **International cooperation on renewable technology and policy research** was expanded through new global intergovernmental mechanisms like REN21 and JREC (Johannesburg Renewable Energy Coalition), regional bodies like MEDREP, public/private partnerships like REEEP (Renewable Energy and Energy Efficiency Partnership), GNESD (Global Network on Energy for Sustainable Development) or the Global Village Energy Partnership. In addition, to these energy policy research and technology transfer oriented collaborations, R&D cooperation for specific technologies intensified. An example is the Global Market Initiative (GMI) for Concentrated Solar Power to launch 5000 MW of new solar thermal power. GMI involves Yemen, Egypt, Jordan, Israel, Tunisia Algeria, Morocco as well as Germany, Spain, the US, Italy and participants from industry, banks and research institutes.
- The US launched since 2003 new international partnerships to further S&T collaboration in carbon friendly technologies, involve major industrial and developing countries and engage industrial partners in specific committees and projects. These new mechanisms are:

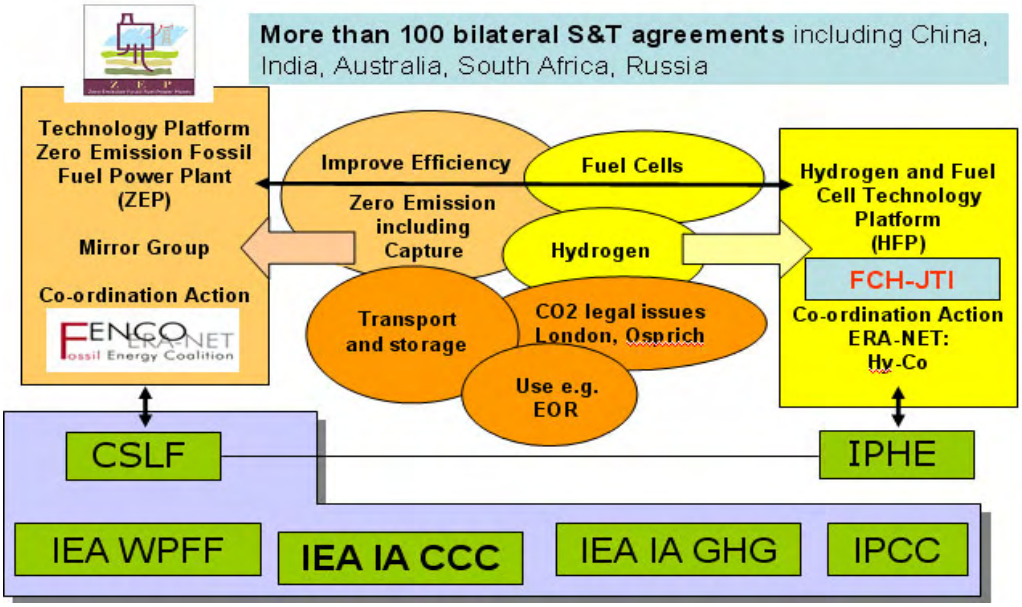
- **The International Partnership for the Hydrogen Economy (IPHE)** with now 17 participating countries and associated research establishments;
- **The Carbon Sequestration Leadership Forum (CSLF)** with at present 22 participating countries and more than 100 stakeholders from industry and NGOs;
- **The Methane to Market Partnership** with 20 participating countries accounting for 60% of global methane emissions and a network of about 300 partners from the agricultural, coal mining, landfill, oil and gas sectors, NGOs and research institutes.

In addition, the latest US 2008 call for a Clean Technology Fund may well cover RD&D financing for clean technologies

- The Gleaneagles G-8 + 5 (Brazil, China, India, Mexico, South Africa) Plan of Action recommended the establishment of **a Global Bioenergy Partnership (GBEP)** which was launched in 2006. The partnership is to accelerate coordination on bioenergy between 12 countries, international institutions, private companies and civil society.
- A host of international institutions (UNFCCC, Energy Charter, IEA, APEC, World Bank) and a range of NGOs (CLASP, ECEEE, IIEC, et al.) are sponsoring new collaborative policy and technology initiatives in the area of energy efficiency. The EU has proposed to launch a new International Framework for Energy Efficiency**.**

Figure 1 illustrates an example of the extensive web of existing international collaboration arrangements for one carbon reduction technology, i.e. Carbon Capture and Storage (CCS).

Figure 1: International S&T Cooperation for CCS



Source: H. Höwener, 2007 and M.Haug, 2008

The many new instruments and mechanisms accelerated international co-operation for most "clean" energy technologies. They bring together both competing and complementary interests, free riders and "cutting-edge" researchers. Individual EU member countries, their industries, NGOs, academia as well as the EU bodies are involved in most of these networks.

They have helped to build closer links among researchers in neighbouring countries, BRICS and developing countries; they raised awareness of the urgent need to invest more in R&D for clean energy technologies at all levels – from politicians to the man on the street; they attracted a new generation of young people to seek careers in energy research; and they engage industry and civil society at every stage of the process.
It is too early to evaluate the effectiveness, "the value added" of these new instruments and mechanisms. It is however safe to conclude that they had an impact; broadened and deepened participation in energy R&D, geographically and by drawing on a larger group of economic agents and decision makers. These instruments have laid the groundwork for dealing with the global energy research priorities of the 21st century. They have been a welcome and necessary development. But, are they sufficient to deal with the changing priorities? Can they deal with the paradigm shift in the role of international S&T energy collaboration?

4) The paradigm shift: the changing role of international energy S&T collaboration

The changing priorities of global energy research in the 21st century spawned a host of new instruments and mechanisms of which a selected number were recapitulated in the earlier two chapters. They grew out of the traditional role of international energy S&T collaboration to build win-win situations for participants as a way to share cost, create knowledge, diffuse technologies establish markets and spread good will.

This traditional role continues to be valid and important. But another role has emerged: International energy S&T collaboration can help high carbon emitting developing countries to develop and adopt carbon neutral technologies as speedily as possible. Some countries consider this "technology option" the most promising climate change mitigation strategy. Thus, technology mechanisms including international S&T collaboration and in addition to market mechanisms such as cap-and trade, have become part of the current post –Kyoto climate change negotiations.

It is premature to speculate what types of collaboration, instruments, concessions, sharing of IPR or financing mechanisms for energy S&T collaboration will evolve during the negotiations. The mere fact that international energy S&T collaboration has become one factor in the post- Kyoto climate change negotiations constitutes an important development, a paradigm shift.

5) Next step: what more is needed in international energy S&T collaboration?

The discussion above highlights that the EU needs to address two separate issues:

- First, develop coordinated strategies for the two distinct roles of international energy S&T collaboration that have emerged: S&T collaboration as tool in the climate change negotiations and the traditional modus operandi of international S&T cooperation in energy;
- Second, ensure that the changing priorities of the 21st century are fully reflected in both the negotiations and the specific calls and programmes for international collaboration at the EU level. Additional new instruments and mechanisms should build on the experiences gained and deliberately fill gaps, add value, and focus European efforts and benefits.

- International energy S&T collaboration as factor in the climate change negotiations demands much closer collaboration among all the concerned EC services and including

Member Countries. Options for new instruments and mechanism need to be evaluated, agreed upon internally and discussed as part of the negotiations. Considering the time schedule of the post-Kyoto negotiations, much uncertainty will remain over the coming few years. The Commission will have little alternative but to develop international S&T collaboration initiatives in a two track, but coordinated manner.

The changing global energy research priorities of the 21st century identified in the beginning of this paper require a reorientation of the content of international energy S&T collaboration. The following paragraphs present a number of specific recommendations.

Priority 1: invent, develop and diffuse clean, affordable and climate friendly energy generation and conservation technologies.

The research areas for low or zero carbon energy technologies are well known and the importance of cross-cutting research, basic research, material research, nano- and biotechnology is universally acknowledged. The major gaps are at this time

- first and foremost, additional financing, including additional financing for international S&T with advanced and emerging economies;
- and second, a more aggressive or focused use of existing international collaboration activities by all parties, but in particular by the EU.

The EU Advisory Group on Energy recommended a 4 fold increase of energy R&D funding in the public and private sector. Despite the enormous profits of the fossil fuel industry in the past years, only a negligible portion has been invested in sustainable energy R&D. The EU should take the initiative to engage the fossil fuel industry more proactively into R&D and international collaboration for sustainable energy.

Another important research gap relates to **bioenergy** research and establishment of appropriate sustainability criteria worldwide. The food, feed and fuel debate can only be resolved through cutting edge technology research in 2nd generation biofuels, research on deforestation and biomass competition in developing countries and through acceptance of worldwide sustainability standards for bioenergy trade. C.E.F. Young has articulated eloquently the full range of trade offs and research needs in his article *"Economic and environmental impacts of biofuels –key research needs"* that form part of these Proceedings. The EU should take a leadership role in resolving these issues – through appropriate research calls, through leadership in the Global Bioenergy Partnership and using its convening and regulatory powers.

A third research gap relates to technologies most appropriate or demanded in developing countries. The list of such technologies recommended in the Stern Report (2007) may serve as a beginning and includes: advanced thermal solar projects; solar home systems, including grid connected PVs; energy efficiency in buildings, transport, commerce and industry related to the specific needs of each region; offshore wind, wave and tidal stream projects; multi-purpose projects to restore degraded lands and watersheds, improve the productivity of land, and provide bio-energy and carbon sequestration as a byproduct etc.

In summary, the EU should consider to focus international energy S&T on

- leveraging more pro-actively the existing international partnerships, instruments and mechanisms for low carbon technologies and energy efficiency;

- bioenergy and biofuels to resolve sustainability and technology issues ;
- new international collaboration activities with priority partners;
- engaging fossil fuel producers in public/private partnerships for climate friendly technologies;
- joint calls with development aid to reach developing countries more effectively.

Priority 2: help societies to transform their energy use and adopt clean and sustainable energy systems

Energy policy research on this important issue is still in its infancy. As soon as the post-Kyoto carbon regime will have been negotiated and the global regulatory framework in support of sustainable energy climate change issues becomes clearer, a broad-based international research effort is needed.
How well and how quickly will different societies adopt clean energy technologies? What will be the effects of these, generally more expensive technologies; of disruptive technologies; and the restructuring of entire sectors? More than 50 countries worldwide depend significantly on fossil fuels revenues and export. How will they deal with the adjustments to a carbon neutral future, and what will be the socio-economic and political consequences?
These topics require international research collaboration. The EU could provide a real value added in initiating and supporting such research, globally or with representative countries.

Priority 3: ensure "access to energy for all", particularly in developing countries to meet the Millennium Development Goals by 2015 and beyond

The traditional development institutions (World Bank, UN Agencies, NGOs, aid agencies including the EU) and private/public partnerships are addressing this challenge. Both affordable and effective technologies and appropriate delivery mechanisms are called for. Experience to date show that both financing and knowledge -about reaching the poor - are major barriers. EU development projects in this area should, therefore, include INCO research components to provide the needed S&T support at an early stage.

The EU can provide "added value" if it focuses its funding and leverage as coordinator on the identified research gaps and targets its interventions both to the R&D leaders (competitor countries and BRICS) and neighboring and developing countries.

The future of international energy S&T collaboration will be reshaped by the policies agreed under a post-Kyoto climate change regime. The approaches adopted by the EU now must help shape these policies while building and extending the existing opportunities and demands for international energy S&T collaboration.

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Acronyms

APEC	Asia-Pacific Economic Cooperation
BRICS	Brazil, Russia, India, China, South Africa
CCS	Carbon Capture and Storage
CERN	European Center of Nuclear Research
CLASP	Collaborative Labeling and Appliance Standards Program
CSLF	Carbon Sequestration Leadership Forum
CTI	Climate Technology Initiative
ECEEE	European Council for an Energy Efficient Economy
EdF	Electricite de France
EOR	Enhanced oil recovery
ERA-Net	European Research Area Network
EURATOM	European Atomic Energy Community
FCH-JTI	Fuel Cell and Hydrogen Joint Technology Initiative
FENCO-ERA-Net	Fossil Energy Coalition ERA-Net
GBEP	Global Bioenergy Partnership
GEF	Global Environment Facility
GHG	Greenhouse Gases
GIF	Generation IV International Forum
GNEP	Global Nuclear Energy Partnership
GNESD	Global Network on Energy for Sustainable Development
GMI	Global Market Initiative for Concentrated Solar Power
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IEA IA CCC	Clean Coal Centre, IEA Implementing Agreement
IEA IA GHG	Greenhouse Gas Programme, IEA Implementing Agreement
IEA WPFF	IEA Working Party for Fossil Fuels
IFMIF	International Fusion Materials Irradiation Facility
IIEC	International Institute for Energy Conservation
INCO-ERA-Net	European Research Area Network for International Cooperation
IPCC	Intergovernmental Panel for Climate Change
IPHE	International Partnership for the Hydrogen Economy
IPR	International Property Rights
ITER	International Thermonuclear Experimental Reactor
JREC	Johannesburg Renewable Energy Coalition
NEA	Nuclear Energy Agency
NEET	Network of Expertise in Energy Technology
MEDREP	Mediterranean Renewable Energy Program
OECD	Organization for Economic Co-operation and Development
REEEP	Renewable Energy and Efficiency Partnership
REN21	Renewable Energy Policy Network for the 21st Century
SBSTA	Subsidiary Body for Science and Technology of the UNFCCC
SEE-ERA-Net	South East European ERA-Net
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

Economic and environmental impact of biofuels – key research needs

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1) Biofuels and global warming

Renewable energy sources are becoming increasingly popular because of their potential to replace fossil fuels and, therefore, reduce carbon emissions. In tropical countries, where greater exposure to the sun, warmer climate and other natural conditions allow faster crop growth, there is tremendous potential for biomass-based energy sources. Rising oil prices have also provided further encouragement for these alternative sources of energy.

There are many different raw materials from which biofuels can be produced, but only two, ethanol and biodiesel, have already been implemented on a large scale.
Sugar cane is the main raw material for ethanol in the tropics, but other sources of biomass can be used for the fermentation process, such as corn and other starches. There is an even wider variety of potential sources for producing biodiesel, with current supplies derived mainly from soybean and other oleaginous plants, such as rapeseed, castor bean and sunflower. In South-East Asia biodiesel is derived mainly from palm oil (*Elaeis guineensis*), originally from Africa, but in Latin America there is also increasing commercial interest in the native species (*Elaeis melanococca* G.). Other possible sources are waste cooking oils, animal fats and even fat-rich waste water.

Because of this vast range of possible sources, biofuels are usually presented as "win-win" substitutes for oil-based fuels, since they enhance economic activity and reduce emissions of greenhouse gases from gasoline and mineral diesel. An additional advantage of use of sugar cane as an energy source is that the residues from the process can be used as fuel to generate both heat (for distilleries) and electricity, by what is called "cogeneration" or "combined heat and power" (CHP), i.e. simultaneous production of heat, usually in the form of hot water and/or steam, and of power, from a single primary fuel. Organic fertiliser can also be obtained from the sugar-rich liquid residues from the process. Similar possibilities for re-using the residues from biodiesel production are being researched.
In other words, biofuels are usually presented as *the* environmental solution for replacing fossil fuels, especially by governments and business associations from tropical countries. But what are the challenges behind this?

2) Potential problems associated with biofuels

In economic terms, the financial feasibility of biofuels depends on the cost of the alternative option, i.e. fossil fuels. However, oil prices are renowned for their instability and uncertainty. In the short run, the volatility of oil prices might be small. But in the long run it is impossible to predict accurately the price of crude in five or more years' time. This is the period required for the infrastructure investment necessary to expand the supply of biofuels and to be ready for operation.

In that sense, sugar cane ethanol is less vulnerable than biodiesel because the production chain is already set up, whereas there is still a long way to go before the biodiesel production chain will be mature. On the other hand, sugar cane ethanol prices are also affected by sugar prices, making this equation even more complicated. It is very likely that the world demand for soybean will, somehow, affect the availability of soy biodiesel, but no serious research has yet been conducted on this subject.

One thing which is already known is that demand for biofuels affects food prices, because of the displacement of part of agricultural production from food to energy use. This has already happened with corn – prices have gone up because of the increasing demand for corn ethanol in the USA – and similar effects are very likely to occur with other crops.

A related problem is the significant negative impact that increasing demand for biofuels is expected to have on the environment. The biomass output required for "green" fuels demands a massive amount of natural and industrial resources, with potentially huge environmental effects. The first point which must be considered is the amount of land that is required for cultivation. In tropical countries, where most biofuel production is expected to be concentrated, expansion of the cultivated area goes hand in hand with increasing deforestation. Therefore, there is an obvious contradiction: biofuels are considered "greener" because they can reduce carbon emissions from fossil fuels. But the main contribution by tropical countries to global warming comes from deforestation.

The most notorious cases are soybean and sugar cane expansion in Brazil and oil palm plantations in South-East Asia. Brazil is currently the world leader in biofuels production and also has a strong hydroelectricity system. On the other hand, it is one of the countries with the largest emissions of greenhouse gases, mainly because of deforestation: the fires as part of the process of converting forests into agricultural land are the leading source of carbon emissions in Brazil.

Producers in the biofuel chain and the Brazilian government argue that most of the converted land is used for cattle ranching and that there is already enough agricultural land available to accommodate the expansion in demand for cultivation. However, soy, sugar cane and other cultivation affects the deforestation process, both directly and indirectly. The direct effect takes the form of straightforward conversion of the deforested area to soy or sugar cane cultivation. The major incentive for deforestation is, nevertheless, indirect. Cultivation increases on former pastures, and cattle ranchers move towards the "agricultural frontier" (Morton *et al.,* 2006; Childs and Bradley, 2007).

The cattle herd in the Cerrado and Amazon regions increased significantly at the time of the soybean boom in the early 2000s. Therefore, the "official" argument that soybean and other crops do no harm to the forest because they are grown on land which has already been deforested would be valid only if pastures were reduced by the same level, a very unlikely assumption. Ranchers who sell pasture land to enhance soybean, sugar cane or any other plantation re-invest the profit to purchase much more pasture land in the Cerrado or the Amazon. A reasonable estimate is that one hectare of land sold to soybean cultivation in the southern tip of the Brazilian Amazon is worth at least five hectares of recently converted pasture land in the heart of the forest (Young *et al.,* 2007).

Hence, the main effect of biofuels is on land prices, because they change land use. The same holds true for the potential impact on food: the higher the demand for biofuels, the more and

better land will be diverted from other uses to supply them. This is one area that must be analysed much more closely in the near future.

A rough estimate gives an idea of the scale of the problem. If the Brazilian vehicle fleet (20 million cars) were the same size as the US fleet (around 180 million cars), in order to supply it with ethanol the total area under cultivation would have to be increased by 100%, all of which would have to be given over to sugar cane plantations. Considering that the current world fleet is around 750 million cars, there would be far-reaching changes in global agriculture, with a major impact on the availability of other crops (Young and Steffen, 2006).

Another problem is raised by the changes in land use patterns. Booming demand for biofuels tends to stimulate monocultivation and mechanised production, affecting traditional uses of land, such as subsistence farming or small-scale family farming. This might worsen the already chronic problem of land concentration in Latin America and could have a major social impact.

Governments and the biofuels industry emphasise that rural employment will increase, with positive effects especially for the very poor and for unskilled labourers, such as manual sugar cane harvesting. They also say that special incentives will be created for family-based, small-scale producers. The Brazilian biodiesel programme, for instance, claims that half of the production will be supplied by small-scale farmers producing from a mix of seeds, rather than soy monocultivation. The official estimates are that 180 000 jobs will be created, directly and indirectly, by the programme. However, an alternative technical analysis indicates that these figures are highly overestimated. Using an input-output model to estimate job creation from the Brazilian biodiesel programme, Lucena and Young (2008) analysed four different scenarios: in the most optimistic 123 000 jobs were created, while in the two more conservative scenarios the figures were 58 000 and 66 000. This suggests that the political support and consistent technical support behind the biofuel programmes have been emphasising the good aspects and omitting the problems. A better understanding of the social consequences of expansion of biofuels requires more accurate modelling than currently being applied.

This also means that job creation has to be discussed in qualitative terms too. Land concentration and rural conflicts, which are to be expected in any expansion of the agricultural frontier, result in displacement of family-based production and expansion of temporary labour. This issue is well documented for sugar cane harvesting, where serious labour problems arise from the very poor working and living conditions of the temporary labourers. By the way, the rural areas where sugar cane plantations were established centuries ago are among the poorest and least developed in Brazil, indicating that the jobs created by the sugar cane plantations are far from being a social solution.

Another important aspect to consider is that biofuels also have impacts other than increasing demand for land. Soil preparation, seeding and harvesting can be problematic. For example, manual harvesting of sugar cane requires burning the leaves, resulting in serious air pollution near the plantations. Refining and distribution of the biofuels can be very energy- or emission-intensive, and proper estimates of the net benefits need to be made. In other words, what is the net emission saving from biofuels when the entire chain is considered? Do they offer a better performance than natural gas vehicles? There is a tremendous lack of studies with consistent methodologies about this.

Similar problems are reported in Indonesia, Malaysia and other South-East Asian countries, with the difference that the main driver of deforestation and land use change there is palm oil cultivation (CSPI, 2005; Greenpeace, 2007). The expectation is that 20% of the European Union demand will be supplied by Indonesia and Malaysia alone, thus requiring voracious expansion of oil-palm plantations to meet this growing demand.
There are many differences between palm oil plantations and perennial harvests. One important distinction is that feedstock transport logistics associated with this kind of biodiesel:
"are less of a problem than with starch-based ethanol production, because the oil-based feedstocks are denser than starch or cellulose, making transport more cost-effective. Further, production of biodiesel is based on simpler technology, which is economically viable even at relatively small scales. (...) However, it is not clear that small producers can refine and purify the product enough to meet modern fuel standards" (Childs and Bradley, 2007, pp 18-19).

Consequently, even though biodiesel production presents some advantages for the producer, compared with ethanol, since it can be incorporated into the fuel mix at any blend without major changes to the engine, it is very likely that the two markets will evolve in parallel. Capital concentration, land property concentration and changes in social structure are very likely to occur, coupled with biodiversity loss in the deforested areas. This will probably trigger an intense debate, since important habitats will be affected, threatening many wildlife species, such as the critically endangered orangutans and Sumatran tiger. The resistance from environmental groups will certainly heat the debate and, unless solutions are adopted – such as a system of certification based on proper environmental standards – this might depress expansion of the tropical biodiesel market in the near future.

This is related to the many imperfections in the trade mechanisms for biofuels. There are still trade barriers and the prevailing tariff escalation systems encourage tropical countries to export feedstock, such as unprocessed molasses and crude, with the final conversion into biofuel – and associated value addition – taking place in the importing country. The impact of these policies on developing countries' efforts towards sustainable development needs to be understood (Dufey, 2007).

3) Technology and innovation

On the technological agenda, a great deal can be learnt from previous experience, such as Brazil's ethanol programme (Proalcool), established in the late 1970s, aiming at substitution of gasoline imports. Proalcool induced considerable advances in the technology of ethanol-fuelled engines. The programme collapsed in the early 1990s, after a series of problems (mismanagement, excessive subsidies, low oil prices and high sugar prices, among others), but the sector was able to maintain stable production after the subsidies were removed, mainly by increasing productivity (cultivation and processing).

The most recent innovation widely accepted by consumers is the "flex-fuel" engine, which accepts different blends of gasoline-ethanol mixture (in some cases, the engine also runs on natural gas too). In the case of diesel engines, flex-fuel switching is not possible. The main challenge is how to obtain the biomass required. For example, castor bean and palm oil are considered technically feasible alternatives to soybean. This would be very desirable, for both

social and environmental reasons, but, again, there are no detailed analyses of the potential impact if this substitution were to be put into practice.

Moves are being made to obtain biofuels from other sources, including native tree and palm species or seaweed. These are still on an experimental scale, and so far they lack the financial feasibility proven by the current options. But it is very likely that the industry will move towards "second-generation" biofuels, including cellulosic ethanol, Fischer-Tropsch fuels, biobutanol and technologies to produce fuel from agricultural residues, trees, grasses and other types of biomass (Childs and Bradley, 2007).

These technological opportunities will certainly differ from one sector to another, depending on the availability of equipment and the existing scientific and technical knowledge. Depending on them, either it will be possible to achieve the required solution easily with existing technologies or the option will give rise to complex problems that will take much more time to solve. But the final answer will not depend exclusively on technical aspects. Other social aspects, such as the social interest in obtaining long-term substitutes for carbon-rich fossil fuels, the willingness to promote fast dissemination of these alternative technologies and the support of public policies throughout this process, will certainly affect the innovation process.

In other words, even if the technical issues are solved, there will be a need for investment in scaling up, adapting engines and existing technologies and establishing an entire chain of suppliers able to deal with these new technologies, and also to regulate the demand in order to avoid instability and to induce consumers to make the change. Research needs to be carried out not only for the necessary technological advances, but also for designing policy instruments that could effectively implement changes in the entire system of fuel production, distribution and consumption.

4) Conclusions

The challenge in terms of radical and incremental innovations necessary for this change is tremendous. As pointed out by Childs and Bradley (2007, p. 23): "To meet the challenge of climate change and displace large proportions of carbon emissions from fossil fuels, biofuels would need to significantly expand their role. Is this feasible? The wedges concept is rooted in the idea that multiple technologies, rather than a single "silver bullet", are required to address climate change."

Consequently, the biofuel industry can play a major role in global sustainability, but this is not something that can be achieved automatically. A pro-active attitude, recognising the many problems involved (as briefly discussed below), is a more effective way to find practical solutions than the current position of trying to deny the potential negative effects and emphasise only the good side. Dufey (2007, p. 1) summarises the key messages for the industry: trade-offs need to be made clear and the domestic consequences of any international expansion of demand for biofuels have to be considered, because "developing countries need to seize the opportunities and appreciate the costs of the biofuels market, identifying those that are most suitable for the achievement of their sustainable development goals."
Two interesting examples of win-win solutions come from the (sugar cane) ethanol industry. At first, the liquid effluent from the ethanol distilleries was discharged into rivers and lakes, causing a major water pollution problem. Later, it was discovered that this organic-rich

residue could be used as fertiliser, reducing production costs. The other example is use of the cane bagasse for energy generation. Instead of being considered solid waste, it has become feedstock for energy generation, and the surplus energy is now sold to the main power grid.

However, these changes do not come spontaneously. Specific policies to bolster competitiveness, to protect the environment and to pursue social goals are needed. One interesting example is development of standards for the biofuels sector and understanding how they can encourage voluntary action compatible with sustainable development goals.

All of this requires social responsibility and appropriate procedures to measure and certify them.

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Socio-economic development

Urbanisation, poverty and sustainability in a development context: key research needs

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This paper will address three questions: What do we know about urbanisation, poverty and sustainability in a development context? What are the key neglected research areas? And within these broad areas, what are some more specific research issues and questions?

1. The current state of knowledge on urbanisation, poverty and sustainability

We know that half the world's population is now urban, and that most urban growth in the next ten years will occur in the urban centres of developing countries, which will be home to 80% of the world's urban population by 2030 and can be expected to triple their area (Angel et al, 2005; UNFPA, 2007, p.1). Although urban population growth rates are slowing, the scale of growth is unprecedented. The demographics, economics and physical characteristics of urban centres vary, with different policy implications (Satterthwaite, 2007; see also Barten, this volume). For example, in some, rapid population growth and a young age profile imply a need for policy attention to the supply of housing land, education and skills training, job creation, and maternal and child health; in others (e.g. much of Latin America, China), ageing of the population has different policy implications. We also know that, although the millennium development target of "significant improvement in the lives of 100 million slum dwellers by 2020" sounds ambitious, it implies that, even if successful, there will be an increase in the number of residents in unimproved 'slums' by 400 million to 1.4 billion, since more than half of the additional urban population in the cities of developing countries will be forced to live in such poor quality living environments (UN-HABITAT, 2006, p. 20).

We are well aware of the scale and implications of urban sprawl for the environment, increasing the cost of providing services, encroaching on peri-urban agricultural land, and straining the natural resource systems on which cities depend for food, water and energy and as waste sinks, although how the socio-economic and physical dimensions of contemporary trends differ from past patterns and why is only partly understood and improved conceptualisation and measurement of the 'urban' are required (Dahly and Adair, 2007; Kennedy, 2007; Ruet et al, 2007; Maconachie, 2007; Marcotullio and McGranahan, 2007; Malaque and Yokohari, 2007; Keivani and Mattingly, 2007; Worldwatch Institute, 2007)[1].

[1] For example, a distinction needs to be drawn between poor countries, where the adverse environmental impacts of urban growth can partly be attributed to the lack of resources to take pre-emptive or remedial action, and middle income countries with flourishing economies (such as China, see Gallagher, this volume) where the technical and financial resources are available, but the drive for industrialisation and economic growth is more powerful than the political will to tackle environmental impacts.

We know a great deal about the technology and engineering of urban infrastructure and utilities (water, waste management, transport, etc), both conventional approaches and solutions that are appropriate to low income countries and urban settlements. Conventional approaches draw on 150 years of experience, since engineers first started to tackle the problems arising from rapid industrialisation and urbanisation, and there is plenty of research in richer countries to evaluate and improve existing technologies for water supply, treatment and distribution; management and treatment of waste water; sewage collection and treatment; transport; construction; land reclamation and flood protection, although of course financial and technological capacity constraints mean that careful choice and adaptation of available technology is necessary for its use in low income urban centres. As will be stressed below, the problems faced by urban centres in a development context are primarily issues of politics, governance, and resource limitations rather than the availability of technological solutions to their problems (Marcotullio and McGranahan, 2007; Satterthwaite and McGranahan, 2007).

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This is not to say that infrastructure technologies used in higher income countries are always suitable for low income countries with rapidly growing towns and cities. The technical and financial demands may make their use unrealistic and alternatives may be more appropriate, especially in low income cities and neighbourhoods. However, I would also argue that many of these technologies are available: supply of water to low income residents through shared supply points, use of runoff and waste water for productive purposes (urban agriculture), soft engineering approaches to flood management, improved pit latrines, simplified/condominium sewers, reedbed sewage treatment, composting and other recycling, improved non-motorised transport, etc (Paterson et al, 2007). Although there are obstacles to their adoption at a sufficient scale to make a significant difference to poor living and environmental conditions, most of these are financial, socio-cultural or political rather than technical.

Many evaluations of urban policies and conventional approaches to service delivery, urban planning and land management have demonstrated that they are inappropriate and unworkable (e.g. Njoh, 1999; Steinberg, 2005; Keiner et al, 2005; Jenkins et al, 2007). Although there is evidence that as wealth and administrative capacity increase, approaches to service delivery, urban planning and land management that are typically used in Northern cities are often more successful in middle income urban centres than they were at lower income levels, it is also clear that poor people in these cities often do not benefit because of their inability to afford the higher costs or their residence in informal settlements. What is also clear is that, even though colonial, post-independence and contemporary efforts to implement urban planning and management approaches modelled on those that have been successful in developed country cities have generally been futile, conventional approaches to service delivery and urban management persist (although the reasons are complex and not always well understood). In particular, research and practice have demonstrated that over-bureaucratic regulation and inappropriate subsidies not only hinder efficiency but also generally benefit a minority, who typically do not include the poor.

It is also obvious that the ‘right to the city’ (meaning access to affordable housing and basic services; secure livelihoods, health and education, mobility to access all these; and the right to participate in decision making) is highly contested – elites and established urban residents are not keen to share urban spaces and opportunities with the poor and newcomers, especially if they are of different nationalities, ethnic groups or religions (Balbo, 2005; Shatkin, 2007).

2. Broad research areas

Concentrating mainly on urban research priorities in Asia and Africa, six broad research areas can be identified. As recent research has been geographically uneven in its volume and coverage, the need for further research in these areas varies from one part of the world to another.

2.1 Globalisation, urban growth, informalisation and marginalisation

There is a consensus that contemporary urban growth is associated with new forms of informalisation, inequality, insecurity and exclusion (economic, cultural, political and physical), as seen physically in the proliferation of gated communities and restrictions on the ability of urban dwellers gain access to and across urban spaces. Some of these trends have been documented more adequately than others (Borsdorf et al, 2007; Douglass et al, 2007; Landau, 2007; Genis, 2007; UN-HABITAT, 2006) and further work is needed to identify and explain the form these changes are taking. To what extent do emerging marginalisation trends counteract or reinforce previous axes of social differentiation, such as ethnicity, religion, caste or gender? What implications do they have for health and ill-health (see Barten, this volume)?

Intensifying economic globalisation, increased private sector participation in the economy and service delivery, and political regime change all have an impact on patterns of urban change, but the precise nature of their role in processes of marginalisation and displacement is poorly understood (Shaw and Satish, 2006; Keivani and Mattingly, 2007). Arguably, attention of the academic community needs to shift from networks of global cities (the 'command and control' centres of the global economy) to understanding the "world of diverse, distinctive cities" through studies that examine the ways in which international influences interact with particular historical, economic and physical heritages (Robinson, 2005, 2006). The implications of globalisation, economic liberalisation and political change for cities' and towns' contribution to the economies of the countries in which they are located and efforts to create liveable urban centres for all have only been studied in relatively few large cities and even fewer small cities and towns (e.g. Laquian, 2005; Newman and Thornley, 2005)[2].

[2] There is a stronger tradition of urban research in some countries than others. In addition, recent developments in some countries have fostered increased attention to urban issues. For example, increasingly, trends in Chinese cities as a result of globalisation and economic liberalisation are not only being studied but also the results being published in internationally available journals. See, for example, Guangwua Wan (Editor), 2007, *Inequality and Poverty in China*, Review of Income and Wealth, Vol 53, No 1; Wu, F. (Editor), 2007, China's New Urbanism, Routledge, London; He, S. and Wu, F., 2007, *Socio-spatial impacts of property-led redevelopment on China's urban neighbourhoods*, Cities, Vol 24, No 3, pp 194-208; Song, Yan and Chengri Ding (Editors), 2007, Urbanization in China: Critical Issues in an Era of Rapid Growth, Lincoln Institute of Land Policy, Cambridge MA; Shen, J., 2007, *Scale, state and the city: Urban transformation in post-reform China*, Habitat International, Vol 31, No 3-4, pp 303-16; Yang, J. and Gakenheimer, R., 2007, *Assessing the transportation consequences of land use transformation in urban China*, Habitat International, Vol 31, No 3-4, pp 345-53. The volume of urban research in South Africa is also considerable, for example, Beall, J., Crankshaw, O. and Parnell, S., 2002, Uniting a Divided City: Governance and Social Exclusion in Johannesburg, Earthscan, London; Watson, V., 2002, Change and Continuity in Spatial Planning: Metropolitan Planning in Cape Town under Political Transition, Routledge, London; Harrison, P., Huchzermeyer, M. and Mayekiso, M. (Editors), 2003, Confronting Fragmentation: Housing and Urban Development in a Democratising Society, UCT Press, Cape Town; Gaule, S., 2005, *Alternating currents of power: From colonial to post-apartheid spatial patterns in Newtown, Johannesburg*, Urban Studies, Vol 42, No 13; de Swardt, C., Puoane, T., Chopra, M. and Du Toit, A., 2005, *Urban poverty in Cape Town*, Environment and Urbanization, Vol 13, No 2, pp 101-12; Parnell, S. and Robinson, J., 2006, *Development and urban policy: Johannesburg's city development strategy*, Urban Studies, Vol 43, No 2, pp 337-55; Dixon, J. and Ramutsindela, M., 2006, *Urban resettlement and environmental justice*

2.2 The costs and benefits of urbanisation

The economic and environmental costs and benefits of urban agglomerations are the subject of much speculation, but the evidence base for most of the statements is extremely weak. The strong association between proportion of the population living in urban areas and national income is undisputed. For example, in India 39% of the country's GNP is generated in 'cities', though they house only 20% of the population (the equivalent figures for Mexico are 80% and 60% (Polèse, 2005). However, the direction of causation (does the emergence and growth of urban agglomerations cause incomes to rise in the long run or are they an outcome of national economic growth?) is unclear and inherently difficult to research (Polése, 2005)[3]. Nor is it clear how the economic and environmental costs and benefits vary between large and small urban centres - although the scale of urban growth is more striking in the megacities, smaller urban centres absorb a much larger proportion of all urban population growth (UN-HABITAT, 2006; UNFPA, 2007; Satterthwaite, 2006). However, the information and analysis available is even weaker for towns and small cities than for metropolitan areas.

2.3 Social and political change in cities

Cities have always been the main arenas for the emergence of political changes and social movements. Research is needed into whether the configurations of the movements, the issues with which they are concerned and their strategies are changing in the light of (a) new global agendas e.g. environmental change, religious revival, and (b) new technologies e.g. ICT. External influences interact with the dynamics of local social and political change in different and sometimes unpredictable ways, influencing the opportunities for more effective and equitable urban policies but also the constraints on their adoption and implementation. It is important, therefore, to understand how the interactions between ethnic, racial, religious and gender groups are changing in urban centres, at both city and neighbourhood levels, especially in those situations where they have provoked violent confrontations that may result in population displacement, locally, nationally or internationally (Konings and Foeken, 2006).

2.4 Urban politics and governance

The fourth broad research area is linked to the trends in the evolution of urban centres identified above and concerns urban governance and politics. For example, we need a better understanding of the circumstances in which urban concentration exacerbates political conflict or promotes more positive state/society engagement. Linked to the former scenario, despite some recent research, we still have a fairly limited and superficial understanding of

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in Cape Town, Cities, Vol 23, No 2, pp 129-39; Lemanski, C.L., 2006, *Desegregation and integration as linked or distinct? Evidence from a previously 'white' suburb in post-apartheid Cape Town*", International Journal of Urban and Regional Research, Vol 30, No 3; Mukheibir, P. and Ziedrvogel, G., 2007, *Developing a Municipal Adaptation Plan (MAP) for climate change: the city of Cape Town*, Environment and Urbanization**,** Vol 19, No 1, pp 443-58**.** While additional work may be needed in countries such as China and South Africa, arguably funders should identify under-researched countries and cities for attention.

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[3] Economists tend to analyse China's economic policies in non-spatial terms, but they have distinctive spatial dimensions. China's urban hierarchy has been strongly influenced by the contrasting economic policies of the pre- and post- liberalisation eras and their spatial dimensions, but its current urban pattern, which concentrates investment in coastal urban areas, also has implications for its economic development and its distributional and environmental outcomes (see Gallagher, this volume).

the implications of inequality, crime and violence for urban governance, politics and the incidence and experience of poverty (UN-HABITAT, 2007).

In order to improve urban governance, the neglect of urban politics needs to be addressed, and the research needs to move beyond simplistic discussions of 'democratisation' or 'clientelism and patrimonialism' to more nuanced conceptual frameworks and empirically grounded analyses. Illustrative research questions include: How do urban governments interact with other political actors, especially given the drive towards private sector participation? What are the drivers for political change and what are the constraints on more participatory and effective urban politics? Why are national political and bureaucratic actors (politicians, civil servants, and professionals) so resistant to tackling problems adequately and appropriately, despite

- having the technology for urban service provision
- knowing that underinvestment in infrastructure and a sclerotic property market/land administration system hinders economic growth and investment
- knowing that disaffected/excluded urban residents pose a threat to political stability
- knowing the direct costs to government and indirect costs to the economy of under-investment in health and education, especially for the poor?

Even where formal/state systems of urban government are weak, urban centres continue to function (e.g. Kinshasa, see Trefon, 2004), demonstrating that existing social relations and traditional ways of organising society can be drawn on to enable people to organise their everyday lives, including delivering services, providing a degree of security, supplying land and housing units (Simone, 2004; Konings and Foeken, 2006). It is, however, clear not only that these systems cannot deal with all the problems of growing cities, because they lack the necessary resources (including transfers from central government on which the vast majority of urban centres depend) and cannot operate at a broad, often citywide level (as required for systems such as water supply, waste management, major transport infrastructure planning and investment) but also that they rarely operate in complete isolation from the state (Tranberg-Hansen, 2004). They need to be studied in order to identify the practical arrangements and social institutions that enable them to operate, the ways in which they are evolving in interaction with the state also needs to be understood, as well as their strengths and limitations with respect to managing urban growth effectively and equitably.

2.5 The dynamics of urban economies

The dynamics of city economies, especially those that are largely informal, are little studied and understood, even in countries with long traditions of systematic data collection (e.g. India), and more often citywide data is scarce, confined to (minority) formal sector enterprises and jobs and unreliable. Economic and employment structure and trends vary between cities, but relatively little hard evidence is available on the factors that influence urban economic trajectories and how these are related to both national economic trends and globalisation forces, despite the existence of some city studies (e.g. Abidjan, Guichaoua, 2006). In practice, most research has been confined to studies of sections of the informal sector (Hansen and Vaa, 2002). Linked to our poor understanding of the economies of individual urban centres in low income countries is the lack of evidence in many countries on the outcomes of attempts by sub-national governments to influence local economic development (but see Rhodes University, 2005; Kennedy, 2007; Shaw and Satish, 2006).

2.6 Climate change and cities

There is a large, if patchy, body of research on the environmental problems created or faced by urban centres, including environment-related shortages of water and energy, air and water pollution, waste management, the unequal exposure of urban residents to hazards and poor environmental conditions, etc. (Marcotullio and McGranahan, 2007) . Until recently, the high degree of uncertainty and controversy over the speed and nature of climate change, together with a preoccupation in low income cities with managing the immediate problems arising from urban growth, meant that the implications of climate change for cities have received relatively little attention. For example, a review of the environmental issues faced by urban settlements in river basins and on coasts in 1996 (Rakodi et al, 1996; Rakodi and Treloar, 1997) found only isolated references to sea level rise and salinisation of ground water, and few other attempts to explore the implications of the emerging evidence on the likely hydrogeological and agricultural changes associated with climate change for cities. However, this is now changing (McGranahan et al, 2007; Satterthwaite et al, 2007).

3. Specific research questions

Within these broad research areas, a number of more specific under-researched questions can be identified.

3.1 The dynamics of urban land and property markets

Even though the dynamics of land and property markets are poorly understood in many developing countries[4], it has become fashionable to promote formalisation and the issue of titles (de Soto, 2001). However, assessments of the social and economic outcomes of existing programmes to formalise urban land and property markets and issue titles are rare (especially outside Latin America). A couple of small case studies of Johannesburg and Dakar are currently under way, but a recent review marvelled at the limited empirical basis for worldwide promotion of a particular approach to supposedly pro-poor land administration (Payne et al, 2007; see also Varley, 2007). Early indications are that large scale titling is difficult and costly to implement in complex administrative and land ownership situations, initiates or exacerbates property market trends that further marginalise the disadvantaged, and does not produce the anticipated benefit of enabling owners to access credit for home improvement and business investment. There are land delivery systems that in practice deliver residential land for middle-low income households at scale and with 'good enough' security in many urban centres. These demonstrate some of the characteristics of policy and land administration that might be more appropriate, especially in rapidly growing low income countries. Clearly, they also have weaknesses, including the development of housing areas in inappropriate locations with adverse environmental impacts; vulnerability to threats to environmental, economic and political threats to residential security; and sometimes the breakdown of social institutions (Rakodi, 2007; see also Baruah, 2007).

[4] There are some exceptions e.g. Dowall, D.E. (2007) Brazil's urban land and housing markets: how well are they working? In Ingram, G.K. and Hong, Y-H. (eds) Land Policies and Their Outcomes, Lincoln Institute for Land Policy, Boston, MA.

3.2 Urban politics

Urban politics is poorly theorised and understood – research on urban management has tended to have a rather apolitical approach, and the relevance of work on Northern cities is often limited in political systems that lack evolved democratic and accountability mechanisms and have different economic structures and funding arrangements (Rakodi, 2004). Emerging trends in urban governance, encouraged by donors, involve municipal governments working with large and small private sector actors, NGOs and faith-based organisations (so-called partnerships), but there is only limited research on how these actually operate in practice and on their outcomes (see, for example, Roque and Shankland, 2007; Baud and Danalakshmi, 2007).

In particular, the political relationships between city and municipal governments and different urban political actors are little studied. More systematic research is needed into how and why some communities have gained a capacity for organisation, enabling them to claim entitlements and interact with government, while others have not, as well as the corollary - how and why have some municipal governments adopted positive approaches to working with low income residents and not others and with what outcomes?[5] The ways in which city size influences urban politics also needs to be investigated – the scope for metropolitan governments to be responsive and accountable might be expected to be less than for local government in a small municipality, although the differences produced by alternative political and administrative arrangements in cities also need to be understood.

3.3 Policy evaluation

Related to these questions is the need for assessments of the outcomes of urban policies, particularly evaluation of fashionable initiatives, adoption of which appears to be spreading increasingly rapidly through demonstration effects, networks of municipal governments and mayors, and donor promotion. For example, although the efficiency, environmental and distributional effects of large-scale private sector participation in water supply/sewerage and refuse collection have been examined (Nickson, 2003; Castro, 2007; Gilbert, 2007), the findings vary and too little is still understood about why the outcomes are so different in different contexts. Increasingly, the evidence that large-scale PSP in utilities is failing to live up to initial expectations is building up. Thus at the same time, renewed research attention to alternative delivery arrangements is required e.g. the strengths and weaknesses of small private and not-for-profit providers, and the outcomes of attempts to reform public sector delivery arrangements (e.g. Myers, 2005 who examines solid waste management in Tanzania and Zambia).

A linked research question concerns policy learning. Much attention has been given, especially by international funders, to identifying and promoting 'best practices', often with limited or negative results. We understand too little about whether and why urban decision

[5] An exception is participatory budgeting, which originated in Brazil and has now spread, with the help of considerable advocacy by international agencies and others, to many other countries. However, the increasing body of critical research indicates that the original positive experiences cannot necessarily be replicated in cities with different social and political circumstances (e.g. Avritzer, 2006). Also, with the devolution of powers and responsibilities to the local level in India, previous research neglect is being replaced by a new interest in local politics, see for example, Harriss (2005); Padiyath (2005); Singh, 2006; Benjamin and Bhuvenaswari, 2006; Jha et al (2007).

makers learn from experience. Often they are reluctant to learn from the experience of their predecessors, which may be related to the characteristics of local urban politics or may indicate poor arrangements for policy monitoring and evaluation. Sometimes they are more willing to learn from the experience of others (especially cities with the economic prosperity and good living conditions to which they aspire), but it is clear that policy transfer often has unpredictable and undesirable outcomes – research could tease out the circumstances in which policy transfer does or does not occur, with successful or unsuccessful outcomes.

3.4 The impacts of climate change on urban centres' natural resource base

Cities depend on natural resource systems for water, food, building materials (especially renewable plant-based materials), and as waste sinks. The potential effects of anticipated climate changes for these natural resource systems are being explored, but their implications for cities in developing countries need to be analysed. Cities are also particularly vulnerable to extreme weather events, with implications for the development of early warning and disaster management systems. A very large proportion of towns and cities are on the coast and potentially affected by sea level rise – research is concentrating on cities in the north, yet more people will be affected in cities in the south, which lack the resources to adapt. The implications of sea level rise for cities in the south need to be explored and alternative coping strategies analysed (Haq et al, 2007; Satterthwaite, 2007; UNFPA, 2007, p. 61).

3.5 Urban economies, household livelihoods, and their policy implications

Urban centres contribute to national economic prosperity and provide livelihood opportunities to their residents, although as noted above, the dimensions and dynamics of urban economies (especially those that are largely informal), their ability to generate work that can be accessed even by poor residents and the outcomes of government attempts to foster local economic development and employment generation are poorly understood. In order to develop improved understanding of the whole picture, research is needed at the urban level, at the household/individual level and on interactions between the two. In the cities of poor countries, it has been inhibited by lack of interest and capacity, and the limited and poor quality data that is often all that is available (Kessides, 2006)[6].

Little of the data used for monitoring and intervening in national economies or that generated from national household living standard monitoring surveys is disaggregated below the regional level, with the result that it is only of limited usefulness for urban research. Datasets that can be disaggregated, for example censuses can, in conjunction with geographical information systems, generate disaggregated socio-demographic data (UNFPA, 2007) but typically include only limited data of relevance to economic and livelihoods analysis. Until regular data collection is improved, research is likely to have partial and selective coverage – it may tend towards the impressionistic unless individual government agencies or research funders are willing to pay for relatively large scale data collection exercises.

[6] Satterthwaite (2004) argued that the incidence of urban poverty is under-estimated because the higher costs of urban living are insufficiently allowed for in analyses. Ravallion et al (2007) re-analyse existing household survey datasets to demonstrate that, allowing for the higher cost of living in urban areas, although a rising proportion of the world's poor live in cities, three quarters of poor people globally are still rural residents (although not in every region), the incidence of poverty in urban centres is less than half that in rural areas, but that the proportion of all poor people who live in urban areas is increasing, partly because of the migration of poor rural people to urban areas, and partly because urban economies cannot provide enough employment opportunities that generate incomes above the poverty level.

It is now well understood that monetary approaches to understanding and measuring poverty, while of some value, neither capture the full situation of poor people nor enable an appropriate set of policies to be developed. It is recognised that some urban born and in-migrant groups are able to take advantage of economic opportunities and improve their wellbeing, although their ability to do so may be limited by economic trends; their access to education, skills and capital; and policy failures and bureaucratic constraints that trap them in poorly serviced and insecure living environments. It is also recognised that many households 'churn' into and out of poverty over time – policies to reduce their vulnerability to impoverishment in bad times so that they can maintain their wellbeing, if not greatly increase their incomes, are receiving increased attention. In addition to safety net and employment promotion policies, measures to increase the security and environmental standards of their living conditions are within the remit of municipal governments. In addition, however, it is recognised that some poor and vulnerable groups (e.g. the chronically ill and disabled, elderly people without family support) cannot improve their wellbeing through their own efforts or participation in the urban labour market, and that long term support is required (Pryer, 2003; Mitlin, 2005).

The identification of appropriate policy sets requires a sound understanding of illbeing, wellbeing and livelihood strategies. The impacts of ill health (e.g. HIV/AIDS) and economic change on urban household livelihoods are little studied (Kabir, et al, 2000, see also Barten, this volume). The human capital resources available to households, their access to urban labour markets and their wider social resources, including their links with rural areas, have implications for their resilience in the face of shocks and stresses - economic, social or environmental changes that may vary according to the size and economic base of urban centres. Most of the research continues to concentrate on rural areas (although see, for example, Kantor and Nair, 2003; Kidanu and Rahmato, 2004), on which urban research needs to build in order to develop appropriate conceptual and methodological approaches.

4. Concluding remarks

The coverage of this paper has been very broad. In all the research areas mentioned, there has been some research, although it is often limited and patchy. It is important that, as well as assessing the outcomes of interventions, new research analyses both the characteristics and underlying dynamics of urban centres, in order to improve understanding of the context in which decision makers intervene. Although the European Research Area is intended to be the cornerstone of a European knowledge economy, aimed primarily at achieving European economic, social and environmental ambitions, the EU also acknowledges global challenges, such as climate change and financial instability, that will affect its future prosperity; that underdevelopment and insecurity limit export markets, increase political volatility and influence flows of migrants and refugees; and its responsibility to poorer countries. Given the leading role of towns and cities in economic development, the environmental impacts of their unregulated expansion, the likely impacts upon them of climate change and the social inequalities within them, a better understanding of urban dynamics that can inform national policies and EU development cooperation is important. Research on these issues has either been neglected (not only by the EU but also by other research funders) or has focused on Northern urban centres without learning from the parallels and contrasts with towns and cities in the South.

It is essential that we make the most of research that has been done, bringing together the outputs from work funded by different agencies and carried out by researchers from different disciplines and ensuring that both researchers and users are aware of the material that is available. Inequalities in access to research outputs are still enormous, with African researchers being most disadvantaged. Thus in addition to funding for new research, knowledge management needs to be encouraged and supported, to enable local researchers to identify questions that are of interest beyond the domestic arena and to avoid duplication. This implies that from the outset, new projects should pay attention to research communication – this does not imply that research should necessarily produce immediately operational results, but that it is important for potential audiences to be aware of work that is under way, to have a role (though not necessarily a determining one) in identifying research questions and approaches, and for researchers to communicate results in ways that different potential audiences can appreciate and use. Skills relevant to these tasks are in short supply: researchers are often not good at identifying research of interest to non-academic users, nor are they good at communicating their findings to non-academic audiences, while even interested users often do not appreciate the functions and strengths of research. When skills on both sides are lacking, there is clearly a potential role for intermediaries able to facilitate communication, but these skills also appear to be in short supply. Even academic research funders are increasingly concerned that the research they fund is widely appreciated by both academic and non-academic audiences, but to realise this objective, they need to pay attention to building up the skills base required.

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Globalization, Development, and S&T: Drawing Lessons from China

Kevin P. Gallagher[1]

A fundamental global challenge that will require a concentrated global research effort is the extent to which S&T policy can be deployed to accelerate economic development and alleviate poverty in and an environmentally sound manner. China has developed S&T capabilities that have had a speedier contribution to economic growth and development at a rate faster than virtually any country since the days of the industrial revolution. Yet, the environmental consequences of such success have been significant. How can developing countries mimic China's success without jeopardizing the environment at home and abroad? Future research needs regarding globalization and development in relation to S&T policy are to fully understand the nature of Chinese development and to examine the extent to which current EU and global economic policy is consistent with such development paths. The implications for this research will not only have policy lessons for S&T policy, but for the EU's global economic policy as well.

Background

Economic development can be seen as "a process of transforming an economy from concentrated assets based on primary products to a diverse set of assets based on knowledge. This process involves investing in human, physical and natural capital in manufacturing and services while diversifying from extractive industries and low-productivity agriculture" (Amsden, 2001). Science and technology policy coupled with integrating into an increasingly globalized marketplace, are key ingredients into the economic development process. Of course, the sources of economic growth and the role of technology are very large questions that plague social scientists. Yet, the emergence of China as both an economic and technology success story begs a further understanding.

Table 1 shows that China, and East Asian countries in general, have experienced unprecedented rates of per capita income growth in the past 25 years. China has grown at an annual rate of 8.6 percent since 1980 (so average incomes double less than every ten years!), much faster than high income countries, and in stark contrast to Latin America and the Caribbean which has grown at a rate of less than one percent per annum.

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Table 1

Growth in GDP Per Capita for Selected Regions, 1960 to 2005

	1960-1980	1980-2005	2000-2005
	(ave. annual percent change)		
High Income	5.7	2.1	2.8
East Asia and Pacific	3.5	6.6	7.2
China	3.4	8.6	8.6
Latin America and the Caribbean	2.9	0.5	1.4

Source: World Bank Development Indicators, 2008

Not only has China been the source of enormous rates of economic growth, but they have significantly reduced the incidence of poverty. Table 2 shows that there has been a significant reduction on poverty in the world economy, both at the $1 per day and $2 per day levels (expressed in terms of Purchasing Power Parity or "PPP" which is an international exchange rate based on basket of goods across countries). The vast majority of change has been in East Asia and the Pacific, where China accounts for almost all of that change.

Table 2

Changes in Poverty Rates in Developing Countries

Region	1980	2004
	(% of population)	
East Asia and Pacific		
$1 a day (PPP)	57.7	9.0
$2 a day (PPP)	84.8	36.6
Latin America and the Caribbean		
$1 a day (PPP)	10.8	8.6
$2 a day (PPP)	28.4	22.2
Middle East and North Africa		
$1 a day (PPP)	5.1	1.5
$2 a day (PPP)	29.2	19.7
Sub-Saharan Africa		
$1 a day (PPP)	42.3	41.1
$2 a day (PPP)	74.5	72.0
South Asia		
$1 a day (PPP)	49.6	30.8
$2 a day (PPP)	88.5	77.1

Source: World Bank Development Indicators, 2008

While China has emerged as the global success story regarding economic growth and poverty alleviation, economic growth has come with significant environmental costs. In 2004 the

Chinese government released the *China Green National Accounting Study Report 2004*. The study calculates that pollution cost China 511.8 billion yuan (US$63 billion) in economic losses in 2004, accounting for 3 percent of GDP. The environmental costs of water pollution, air pollution, and solid wastes and pollution accidents accounted for 55.9 percent, 42.9 percent, and 1.2 percent of those total costs.

Two key ingredients for China's success at obtaining growth and poverty alleviation have been China's strategic science and technology policies as well as their strategic integration into global markets. A detailed understanding of both strategies and analyses of the relative importance of each is a key research need to help address the problems associated with globalization and development for the world at large.

1) China's S&T policies and impacts in comparative perspective

S&T policy has been a cornerstone of China's industrial development. Beginning in the early 1980s China put in place a number of policies that not only aimed at conducting basic research but that also put equal emphasis on the deployment and diffusion of technology as well. In terms of development policy and strategy, it is important to emphasize that China's technology and industrial development is not solely due to opening up to global markets. Integrating into world markets has been important for China but it has been part, not all of the strategy. This stands in stark contrast to Latin America and the Caribbean, where opening up to global markets was seen as an end in itself, not as a means to compliment domestic development policy. The result has been an acceleration in technology-centered industrialization in China, and a decline in Latin America.

Table 3 provides a snapshot of China's key S&T policies between 1982 and 2000.

Table 3

Development of China's National Innovation System

Policy	Dominant Feature	Year
Key technology R&D program	Encouraging efforts in key technologies	1982
Resolution on the reform of S&T system (CCCP)	Adopting flexible system on R&D management	1985
Sparkle system 5	Promoting basic research in agriculture 1	1985
863 program	High-tech promotion	1986
Torch program	High-tech commercialisation, high-tech zones	1988
National S&T achievements spreading program	Promoting product commercialisation	1990
National engineering technology research centre program	Technology transfer and commercialisation of research	1991
Climbing program	Promoting basic research	1992
Endorsement of UAEs by SSTCC	Promoting university and industry linkage	1992
S&T progress law	Technology transfer, S&T system reform	1993
Decision on accelerating S&T progress (CCCP)	Promoting URI-industry linkage	1995
Law for promoting commercialisation of S&T achievement	Regulating the commercialisation of S&T achievement	1996
Super 863 program	Commercialisation, break-through in key areas	1996
Decision on developing high-tech industrialization	Encouraging technology innovation and commercialisatio	1999
Guidelines for developing national university science parks	Accelerating the development of university science parks	2000

Source: (Xiwei and Xiandong, 2007)

What stands in stark contrast to "reform" in places such as Latin America and the Caribbean, China's S&T operations start with a big push from the government but then quickly establish

linkages with the private sector. Table 4 shows the evolution of R&D in China from 1987 to 2003 where the number of R&D institutes increased by 67 percent. By 2003 however, the number of public institutes decreased while the private sector (enterprise) led institutes more than doubles. This trend is mimicked in terms of spending. In 1987, 60.7 percent of R&D expenditure was for public institutes, by 2003, 62.4 percent of expenditure was to the private sector. Expenditure and policy has not been horizontal. China has targeted a handful of sectors in electronics, semiconductor, and automotive to eventually serve as "national champions".

Table 4

Evolution of R&D in China, 1987 to 2003

	Number of R&D Institutes		R&D Expenditure *(in 100 million yuan, %)*	
	1987	***2003***	***1987***	***2003***
Public Research Institutes	5,222	4,169	106.8 (60.7)	399 (25.9)
University R&D Units	934	3,200	7(4)	162.3(10.5)
Enterprise R&D Units	5,021	11,300	62.1(35.3)	960.2(62.4)
Total	11,177	18,669	175.9(100)	1521.5 1521.5(100)

Source: (Xiwei and Xiandong, 2007)

Compared to Latin America and the Caribbean (LAC), a region of the world where reform has largely meant the retreat of the state in all types of economic affairs, the results for China are striking. Table 5 shows that on average, more patents are filed in China each year than all the LAC countries combined. What's more, whereas in LAC only 13 percent of all patents are by residents, in China that figure is over 75 percent.

Table 5

Selected Science and Technology Indicators

	1980 - 2005	2000 - 2005
East Asia and Pacific		
Patent applications, nonresidents	27,119	64,235
Patent applications, residents	17,387	44,106
Patent applications, resident share	**64.12%**	**68.66%**
Research and development expenditure (% of GDP)	0.89	1.09
Scientific and technical journal articles	11,505	24,804
China		
Patent applications, nonresidents	24,236	58,876
Patent applications, residents	18,785	43,509
Patent applications, resident share	**77.51%**	**73.90%**
Research and development expenditure (% of GDP)	0.98	1.21
Scientific and technical journal articles	10,386	22,979
Latin America and the Caribbean		
Patent applications, nonresidents	19,044	29,850
Patent applications, residents	3,792	4,056
Patent applications, resident share	**19.91%**	**13.59%**
Research and development expenditure (% of GDP)	0.57	0.57
Scientific and technical journal articles	9,666	16,472

Source: World Bank Development Indicators, 2008

These efforts to indigenously develop technologies and to bring such technologies to market have been coupled with a targeted but aggressive acquisition of foreign technologies through foreign direct investment (FDI). The strategy has been to either develop a sector or technology nationally, or to "import" the technology through FDI while ensuring that the foreign firms partner or link with domestic firms to that the technology can be absorbed in the larger economy. Table 6 shows that the majority of foreign electronics firms in China are either joint ventures or domestic/state-owned enterprises (SOEs). Given the large nature of the economy and the fact that China serves as an export platform, China has had a great deal of bargaining power. It has succeeded in establishing joint ventures and linkages to the local economy. Whereas national LAC firms only capture approximately 5 percent of the inputs of foreign firms, in China that number is well over 20 percent (Gallagher and Zarsky, 2007).

Table 6

China: Major Consumer Electronics Firms by Ownership Type

Sector	*Foreign-Owned*	*Joint-Ventures*	*Domestic Firms and SOEs*
Mobile Phones	Motorola	Motorola/Eastcom Nokia/Capitel, Southern Siemens/Mil Subsidiaries Samsung/Kejian Sagem/Bird	TLC
PCs	HP Dell	IBM/Great Wall Toshiba/Toshiba Shanghai Epson/Start Taiwan GVC/TCL	Lenovo Founder Tongfang
"Brown Goods"		Sony/SVA Philips/Suzhou CTV Toshiba/Dalian Daxian Great Wall Electronics/TCL	Changhong Konka Hisense Skyworth Haier Panda Xoceco
"White Goods"	Siemens	Samsung/Suzhou Xianxuehai Electrolux/Changsha LG/Chunlan Mitsubishi/Haier Sanyo/Kelon Sigma/Meiling Hong Leong/Xinfei Toshiba Carrier/Midea	Changling Gree

Source: Rodrik, 2006.

In LAC it has been found that FDI has "crowded out" domestic investment and contributing to the considerably low levels of total investment in the region. China's S&T policies and industrial development strategy is credited with "crowding in" domestic investment, leading to an increase in overall investment, and accelerating economic growth (Agosin and Mayer, 2000). Table 7 shows how China and LAC have both significantly increased their levels of FDI since 1980, but in China total investment is almost 40 percent of GDP and in LAC total investment (Gross Fixed Capital Formataion or GFCF) has dropped to less than 20 percent of GDP.

Table 7

FDI: Crowding Out Domestic Investment?

		1960-1980	***1980-2005***	***2000-2005***
East Asia and Pacific				
	FDI/GDP	0.4	2.3	2.7
	GFCF/GDP	24.6	34.9	34.8
China	FDI/GDP	0.02	2.5	3.2
	GFCF/GDP	26.2	38.2	39.5
Latin America and the Caribbean				
	FDI/GDP	0.8	1.9	3.1
	GFCF/GDP	21.9	20.0	18.9

Source: World Bank Development Indicators, 2008

Government-led S&T policy coupled with targeted FDI policy has led to the deployment and global diffusion of Chinese products in the world economy. High technology exports as a percent of total manufacturing exports in China, East Asia and the Pacific (EAP), and LAC from 1992 to 2007. High technology exports are now over 30 percent in the Chinese case, but have dropped below 15 percent in LAC.

The most dramatic depiction of Chinese high technology penetration of world markets is in terms of its global competitiveness. Table 8 shows the percentage of high technology exports of a country divided by global exports of high technology (your country's share of global high tech exports) exports. In 1980 China was number 99 on the list, exporting far under 1 percent of global high tech exports. By 2005 China is number 2, if you incorporate Hong Kong China is now number 1.

Table 8

China: Climbing the Ladder in High Tech Exports

	1980		1985		1990		1995		2000		2005	
	Country	Share	Country	Share	Country	Share	Country	Share	Country	Share	Country	Share
1	USA	27.0%	USA	25.3%	USA	22.3%	USA	18.1%	USA	18.7%	USA	12.6%
2	Fmr Fed. Rep. of Germany	14.1%	Japan	17.3%	Japan	16.1%	Japan	15.2%	Japan	10.8%	China	12.4%
3	Japan	11.8%	Fmr Fed. Rep. of Germany	11.5%	Fmr Fed. Rep. of Germany	11.6%	Germany	8.8%	Germany	7.4%	Germany	9.2%
4	United Kingdom	10.5%	United Kingdom	8.5%	United Kingdom	7.5%	Singapore	6.9%	Singapore	5.8%	Japan	6.9%
5	France	7.7%	France	6.8%	France	6.6%	United Kingdom	6.8%	United Kingdom	5.5%	China, Hong Kong SAR	5.9%
6	Netherlands	4.1%	Italy	3.6%	Singapore	4.0%	France	5.8%	France	5.0%	Singapore	5.6%
7	Italy	3.8%	Netherlands	3.3%	Netherlands	3.6%	China, Hong Kong SAR	4.2%	China, Hong Kong SAR	4.5%	Rep. of Korea	4.9%
8	Switzerland	3.0%	Canada	3.0%	Italy	3.5%	Rep. of Korea	4.2%	Rep. of Korea	4.4%	France	4.5%
9	Canada	2.5%	China, Hong Kong SAR	2.3%	China, Hong Kong SAR	2.9%	Netherlands	3.5%	China	4.0%	United Kingdom	4.5%
10	Belgium-Luxembourg	2.3%	Singapore	2.2%	Rep. of Korea	2.8%	Malaysia	3.3%	Malaysia	3.7%	Netherlands	4.1%
11	Sweden	2.1%	Switzerland	2.2%	Switzerland	2.2%	Italy	2.5%	Netherlands	3.7%	Malaysia	3.0%
12	Singapore	1.7%	Sweden	1.9%	Canada	2.2%	China	2.1%	Mexico	3.4%	Belgium	2.7%
13	China, Hong Kong SAR	1.3%	Rep. of Korea	1.8%	Sweden	1.8%	Canada	2.1%	Canada	2.5%	Mexico	2.6%
14	Rep. of Korea	1.1%	Belgium-Luxembourg	1.6%	Belgium-Luxembourg	1.6%	Mexico	1.8%	Ireland	2.3%	Ireland	2.1%
15	Poland	1.0%	Ireland	1.3%	Malaysia	1.6%	Switzerland	1.8%	Italy	2.0%	Italy	1.9%
16	Austria	0.9%	Malaysia	1.1%	Ireland	1.4%	Sweden	1.7%	Philippines	1.8%	Switzerland	1.8%
17	Denmark	0.9%	Denmark	0.8%	Austria	1.1%	Ireland	1.6%	Belgium	1.5%	Canada	1.6%
18	Malaysia	0.8%	Austria	0.7%	Spain	1.0%	Thailand	1.5%	Sweden	1.5%	Thailand	1.4%
19	Ireland	0.7%	Spain	0.7%	Denmark	0.9%	Belgium-Luxembourg	1.5%	Thailand	1.5%	Philippines	1.3%
20	Spain	0.6%	Poland	0.5%	Thailand	0.7%	Spain	0.9%	Switzerland	1.4%	Sweden	1.3%
21	Australia	0.4%	Israel	0.5%	China	0.7%	Finland	0.8%	Finland	1.0%	Spain	1.1%
22	Finland	0.3%	Czechoslovakia	0.4%	Finland	0.5%	Denmark	0.7%	Spain	0.8%	Hungary	0.9%
23	Norway	0.3%	Brazil	0.4%	Israel	0.4%	Austria	0.6%	Israel	0.7%	Finland	0.9%
24	Portugal	0.2%	Finland	0.4%	Australia	0.3%	Australia	0.4%	Denmark	0.6%	Denmark	0.9%
25	Hungary	0.2%	Norway	0.3%	Norway	0.3%	Israel	0.4%	Hungary	0.6%	Austria	0.7%
26	India	0.1%	Australia	0.3%	Brazil	0.3%	Philippines	0.3%	Austria	0.6%	Czech Rep.	0.6%
27	Argentina	0.1%	Portugal	0.2%	Czechoslovakia	0.3%	Norway	0.2%	Indonesia	0.5%	Brazil	0.5%
28	So. African Customs Union	0.1%	Hungary	0.2%	Fmr Yugoslavia	0.2%	Czech Rep.	0.2%	Brazil	0.5%	Israel	0.4%
29	Indonesia	0.1%	China	0.1%	Mexico	0.2%	Indonesia	0.2%	Australia	0.3%	Indonesia	0.4%
30	Philippines	0.1%	Philippines	0.1%	Poland	0.2%	Brazil	0.2%	Czech Rep.	0.3%	Poland	0.3%
...	...	...										
...	...	...										
99	China	0.0%										

Source: Gallagher and Porzecanski, 2008

The policies that China has followed to couple its S&T policy with industrial development are numerous. In addition to subsidizing learning through government-led R&D efforts and to linking foreign and domestic private firms with domestic firms, China has orchestrated a host of other key policies as well. Perhaps the most well-known is its exchange rate policy. China has kept its exchange rate fairly undervalued during this entire reform period. This has had two effects. First, exports are cheaper from China thus leading to increased exports and FDI. Second, China's enormous reserves allow it to invest in more S&T. Another key element is financial policy. Whereas the short term interest rate in most of LAC is well over 10 percent, average interest rates for local firms in China has been 2.7 percent. What's more, the Chinese diaspora has been very active in securing capital for domestic firms (Mesquita Moreira, 2007).

China's rise of a national innovation system that also led to a virtual take-over of the global high technology market is unprecedented. This short sketch of the dynamics of this rise is only the very general contours of phenomena that needs to be researched in detail not only so that the EU can understand the dynamics of development and how other countries might mimic this experience, but also so that the EU can form partnerships with different aspects of the Chinese S&T apparatus and directly benefit.

2) Implications for Theory and Policy

China's rise has numerous implications for development theory and policy. In enabling the technological capacity of new industries, markets do not give the correct investment signals when there are high and uncertain learning costs and high levels of pecuniary externalities. In other words, technological dynamism that leads to diversification is not guaranteed by market reforms alone. Weak capital markets, restrictive intellectual property laws, lack of

information, and poor coordination, imperfect competition and the need for scale economies, under-investment in technologically dynamic sectors can occur (Arrow, 1962; Lall, 2005). To correct for these market failures China has encouraged joint venturing with technological transfer agreements with foreign firms to learn technological capabilities, in addition they have invested heavily in higher education and publicly funded research and development. What's more, China has selectively loosened intellectual property rules to allow for learning and supported innovative firms through government procurement, export subsidies, subsidized capital, and tariff protection (Amsden, 2001; Lall, 2005).

Human capital formation is also essential for dynamic economic growth and diversification. Once again, private markets fall short of supplying human capital at a socially optimal level. There are numerous arguments why markets undersupply education and that governments should intervene to increase the supply of educated workers. Basic literacy and education has positive externalities such as improved health and better participation in democratic processes, in other words the social rate of return on education is higher than personal investment. With respect to learning in private firms, firms may under-invest in the training of their workers because of fears of high labour turnover (Rodrik, 1992). East Asian tigers—like developed countries before them—spent a great deal of effort providing education and training to their people. This was done by spending a significant amount of funds on education (including providing scholarships to obtain PhDs in developed countries), clustering schools in export processing zones, requiring that foreign firms higher nationals and train them on the job, and subsidizing training programs in domestic firms (Amsden, 2001).

Essentially nations have a choice to either further liberalize trade or to promote learning economies by government intervention. It is clear from this brief discussion early that China has engaged in a careful sequencing of both. Whereas LAC fully liberalized their economies fairly quickly, the discussion above shows that China strategically and sequentially has globalized its economy.

Although this is largely the path taken in the 18th and 19th Centuries in Europe and the United States, the mid-20th Century in Japan and the late 20th Century by South Korea, Taiwan and now by China, following such a path has been highly criticized for three reasons. First, governments can be pathetic in picking "winners" for industrial policy. Many governments have tried to adopt pro-active policies and have failed miserably—in other words meeting market failures with government action often leads to government failure. Governments have been criticized for not being able to pick winning sectors to focus on. Indeed, there are many examples of governments picking "losers". South Korea and Taiwan are often cited as success stories but Indonesia, Nigeria, and Brazil have had failures that have received relatively less attention in scholarly circles. (Burton, 1983; Evans, 1995; Kohli, 2005). In addition, subsidization and government involvement has been shown to accentuate "rent-seeking" behaviour that make it additionally difficult for developing country governments to let go of projects that aren't going well or that have already reached maturity (Krueger, 1996).

These critiques are quite valid. Of course, without the proper policies in place, government intervention can create more problems than they correct for. However, the most successful cases in large part circumvented these problems because governments were "embedded" in the private sector and where the state enforced discipline on the private sector.

Although trade policy has traditionally been viewed as not the most economically optimal arena to address market failure, it may be appropriate for two reasons. First, because trade liberalization in the face of persistent market failure can actually "globalize" or accentuate market failure and therefore trade policy is the closest to the market failure. Take for example, high technology electronics. This industry has become more concentrated than the world oil industry at its cartel peak, despite declining prices. For hard drives, five firms account for 85 percent of sales, in personal computers the top four firms in 2004 control 44 percent of the worldwide market—up from 27 percent in 1996 (Ernst, 2004). "Breaking in" to highly oligopolistic markets is hard to do. The only successful case has been ACER computers from Taiwan, which had high tariffs, restrictions on foreign investment, and government subsidized credit and learing (Amsden 2001).

To circumvent the rent-seeking problem, political scientists have shown that successful industrializers have had states that were "embedded" in the private sector while maintaining "autonomy" from sectional elite interests seeking rents. State agencies that are charged with correcting market failures have to maintain constant communication and input with the private sector (Evans, 1995). Perhaps most importantly, the problem of picking winners problem has been circumvented by having a good deal of discipline for private actors. Alice Amsden (2001) has referred to the need for "reciprocal control mechanisms. A control mechanism is "a set of institutions that disciplines economic behaviour based on a feedback of information that has been sensed and assessed". For the East Asian success stories, the key principle behind their use of control mechanisms was "reciprocity".

In other words, firms have performance requirements that when they aren't met are no longer supported. The most successful industrializers were able to abandon projects that were not performing whereas others where perpetuated because bureaucrats became hijacked by business interests who became dependent on the state.

A major research question for the Chinese case is to what extent China is getting the political economy right? Research into the Chinese case - in comparison with LACs - will also have great implications for other developing countries hoping to deploy an S&T policy for development. Research should focus on what are the proper institutions for S&T-based industrial development - ex-post research on success *and* failure. China can help us understand how developing countries can better balance FDI and indigenous development; how to import technology through imports and licensing at a "fair" price; how to either "start up" an NIS or spur an NIS to "catch up?" The EU is at too high a level of development to mimic China's policies. Indeed, in many ways the EU had analogous policies to China in the 19th and early 20th centuries. Understanding China will help the EU tailor improved aid, trade and development policy. Understanding China's successes (and failures) will also provide opportunities for EU agencies and private entities to partner with and help benefit from Chinese success.

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Food security, agriculture and resource

Food security and sustainability, inequalities and global governance: key research needs on climate change and food security

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Abstract

Food security depends on multiple social, political and economic determinants in addition to the environmental factors affecting food production. It is underpinned by effective food systems, which comprise a number of activities (producing food, processing, packaging and distributing food, and retailing and consuming food) which lead to associated outcomes (e.g. food availability, access to food and food utilisation). As food security is diminished when food systems are disrupted or stressed, food security policy must address the whole food system. Climate change will add to the difficulties of existing food insecure populations throughout the world. Research is required that will: i) permit intensification of production in a sustainable manner; ii) facilitate the development of new institutional arrangements at regional levels; iii) encourage adaptation throughout the food system at a range of levels; and iv) identify the most suitable spatial level at which adaptation strategies might be implemented.

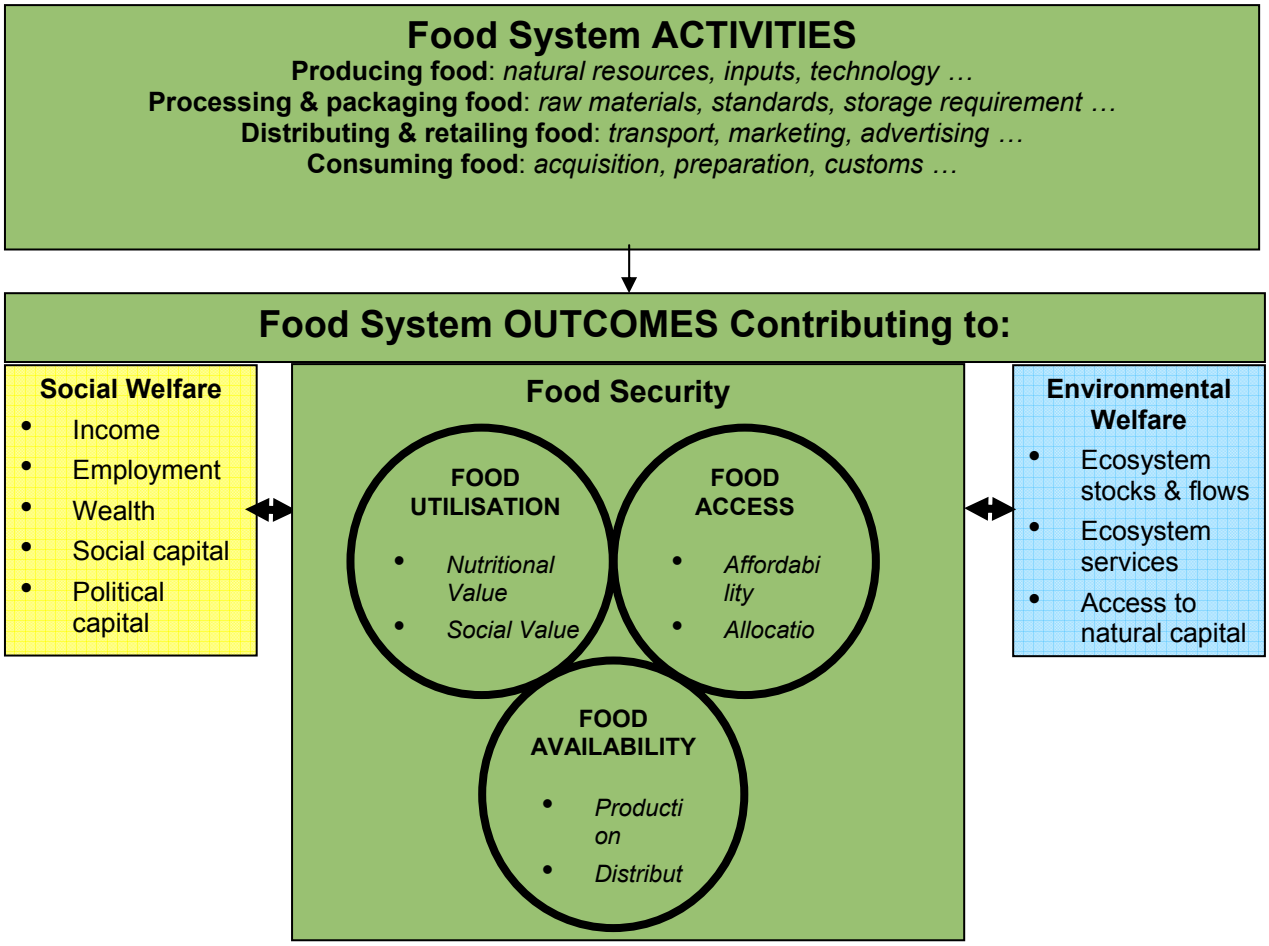
Climate change and food security

Although climate change may benefit crop production in some parts of the world, especially northern latitudes above about 55^{o} where warmer temperatures may extend the growing season, there is growing concern that changes associated with climate will further complicate achieving food security for those in many parts of the developing world. This is due to the observed and predicted deleterious impacts of climate change on agriculture, in particular in tropical and sub-tropical countries (Fischer et al., 2001; Parry et al., 2004; Stern, 2006). There are three main factors underlying the concern. First, many parts of the developing world are expected to experience significant changes in temperature and rainfall patterns. Climate assessments for southern Africa, for instance, conclude that the region will become warmer and drier (Hulme et al., 2001). A temperature increase of 2-5°C is predicted over coming decades (IPCC, 2007) and increasingly variable rainfall is anticipated, with the region becoming generally drier, especially in the east (Scholes and Biggs, 2004). An increase in extreme events (both droughts and floods) is also anticipated (Tyson et al., 2002). The consequence of these combined changes is expected to be reduced yields of several staple food crops (Lobell et al., 2008). Second, developing economies are particularly sensitive to

the direct impacts of climate change given their often heavy dependence on agriculture and natural resources, and because of their high poverty levels and geographic exposure (Stern, 2006). Finally, many people in the developing world depend directly on agriculture as their primary source of food, and negative impacts on crop yield will affect total crop production and thereby overall food supply at the local level.

While there has been considerable progress in understanding the impact of climate change on crop yield, assessments of climate change effects on food security require many other factors to be considered (Gregory and Ingram, 2008). Food security is the state when 'all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life' (FAO, 1996). So, while production is clearly a critical element contributing to food security, many other issues must also be incorporated. Food security is concerned not only with food availability (production, distribution and exchange) but also with access to, and utilisation of, food so that studies which focus only on crop production provide only a partial assessment of food security – environmental change relationships (Gregory et al., 2005; Ericksen, 2008). Food security is underpinned by effective food systems which comprise a set of dynamic interactions between and within biogeochemical and physical environments. They include a number of activities (producing food, processing, packaging and distributing food, and retailing and consuming food) which lead to associated outcomes (e.g. food availability, access to food and food utilisation) all of which contribute to food security (Fig. 1). As food security is diminished when food systems are disrupted or stressed, food security policy must address the whole food system.

Figure 1. The components of food systems (from Ericksen, 2008)



Food systems may be simple, as in the case of a subsistence farmer who produces, processes and consumes food on farm. However, there are comparatively few individuals or households in the world that are totally self-reliant for food throughout a year, and in almost all cases there is an element of bartering, exchange, or the cash economy to bring food into the household. In many places the food system has changed radically in the last century and continues to become increasingly complex (Barling, 2004). The intensification of agricultural production has been accompanied by profound changes in the organization of food systems around the world including changes in distribution, marketing, affordability and preferences for particular food items. These changes are especially obvious in the USA and Europe where market globalization has occurred with global sourcing of products by retailers direct from producers in the case of fresh fruit and vegetables and from a few, large manufacturers for other food products. Such changes have also shifted economic and political power from farmers to retailers, from national legislative bodies to regional and global organizations, and from the state to multinational corporations. For example, in a study of selected European OECD countries, while the food system has some 160 million consumers of whom about 3.2 million are also farmers or food producers, the link between these groups is increasingly determined by the small number of food processors/manufacturers (about 90,000) and the even smaller number of buyers (about 100) for the supermarket chains (Grievink, 2003). Globalization has diminished the impact of climate variability and of climate change on the food security of these regions through multiple mechanisms.

In contrast, in much of the developing world the situation is very different with climate directly affecting food security, especially for the poorest sections of society (Fischer et al., 2005; Mano et al., 2007). There is particular concern regarding southern Africa, where *per capita* food production has stagnated or decreased in the last decade and regional dependence on food aid is increasing (Arntzen et al., 2004). While this net decline in *per capita* food production has been partly met through commercial imports and food aid, in many cases the poorest populations of southern Africa are simply eating less than the recommended calorific intake for a healthy lifestyle. The reasons for the declining *per capita* production are complex and include issues of structural imbalance, poor governance, socioeconomic decline and HIV/AIDS (Mano et al., 2007). The impacts of sudden shocks such as drought are felt, then, on top of ongoing long-term stresses (such as poor market access, poverty and lack of education), and the low ability to cope with such shocks and to mitigate long-term stresses means that the employment of coping strategies that might be available to others, is at too high a cost or, simply, unavailable. Typically, reliance on purchased food increases in drought years due to losses in food production leading to an increase in poverty due to the synergistic action of other drivers such as rising food prices and unemployment. For example, Scholes and Biggs (2004) reported that the food security crisis in southern Africa in 2002-2003 was not simply a direct result of drought but a consequence of multiple factors of which issues of access and entitlement were more acute than those of lost production *per se*.

Adaptation to climate change

The major emphasis of climate change/food security research over recent years has been concerned with the impacts of climate change on crop yield. Adaptation of crops to cope with changed temperatures is possible and various modeling exercises have demonstrated what might be possible. For example, simulation of production for cropping systems in northern

and central Italy showed that the combined effects of increased [CO_2] and climate change would depress crop yields by 10-40 % if current management practices were unamended largely because the warmer air temperatures would accelerate the phenology of current cultivars (Tubiello et al., 2000). Through a combination of early planting of spring and summer crops and the use of slower-maturing winter cereal cultivars, though, the model indicated that it should be possible to maintain present yields. However, a major caveat to this conclusion was that 60-90% more irrigation water was required to maintain grain yields under conditions of climate change; this water was assumed to be available (Tubiello et al., 2000). More recently, elements of crop adaptation to extreme weather events have been explored with genotypic variation and adaptation able to compensate for several of the negative impacts on unadapted productivity (e.g. Fuhrer et al., 2006; Challinor et al., 2007).

New cropping systems which are resilient to changed climate conditions are required. It is highly probable that the changes of climate and [CO_2] will occur sufficiently slowly that changes to sowing date, cultivar, crop and other management practices will allow at least some adaptation of the production system by farmers. Several adaptations are conceivable in the timescale available including:

- Crop selection to determine mechanisms and sources of durable disease resistance
- Crop selection to identify mechanisms and sources of resistance/resilience to abiotic stresses including drought and cold
- Genetic enhancement to cope with more variable growing conditions
- Development of new crops to take advantage of more favorable growing conditions

Climate change may also bring new pests, diseases and weeds to add to the constantly changing populations of plant pathogens (Strange and Scott, 2005). It is already clear that some pests will be able to invade new areas and become increasingly problematic for the maintenance of biodiversity, the functioning of ecosystems and the profitability of crop production. Some pests which are already present but only occur in small areas, or at low densities may be able to exploit the changing conditions by spreading more widely and reaching damaging population densities. Aphids for instance, key pests of agriculture, horticulture and forestry throughout the world, are expected to be particularly responsive to climate change because of their low developmental threshold temperature, short generation time and dispersal abilities (Sutherst et al, 2007).

Although climate clearly affects local production, food security of that same local population can be significantly affected by many other institutional issues operating at local, regional and global scales. The corollary of this is that the opportunities for adaptation to the effects of climate and other environmental changes to achieve food security are more numerous than simply adapting to improve food production (Fig. 2). Adaptation options to ensure food security will involve facets of the whole food system including issues related to livelihoods, international trade in food, marketing and changes in consumption patterns.

In the developed world advances such as better seasonal weather forecasting, improvements in processing and packaging food, and increased international food distribution will continue to lead to benefits across the food system and reduce food insecurity. Such advances include better prediction of demand for certain foodstuffs and more reliable sourcing and distribution within local, regional and global markets allowing reductions in waste and cost, and serving

customers better. Increasingly sophisticated information and management systems are available to cope with climatic and other shocks, and to adapt to change.

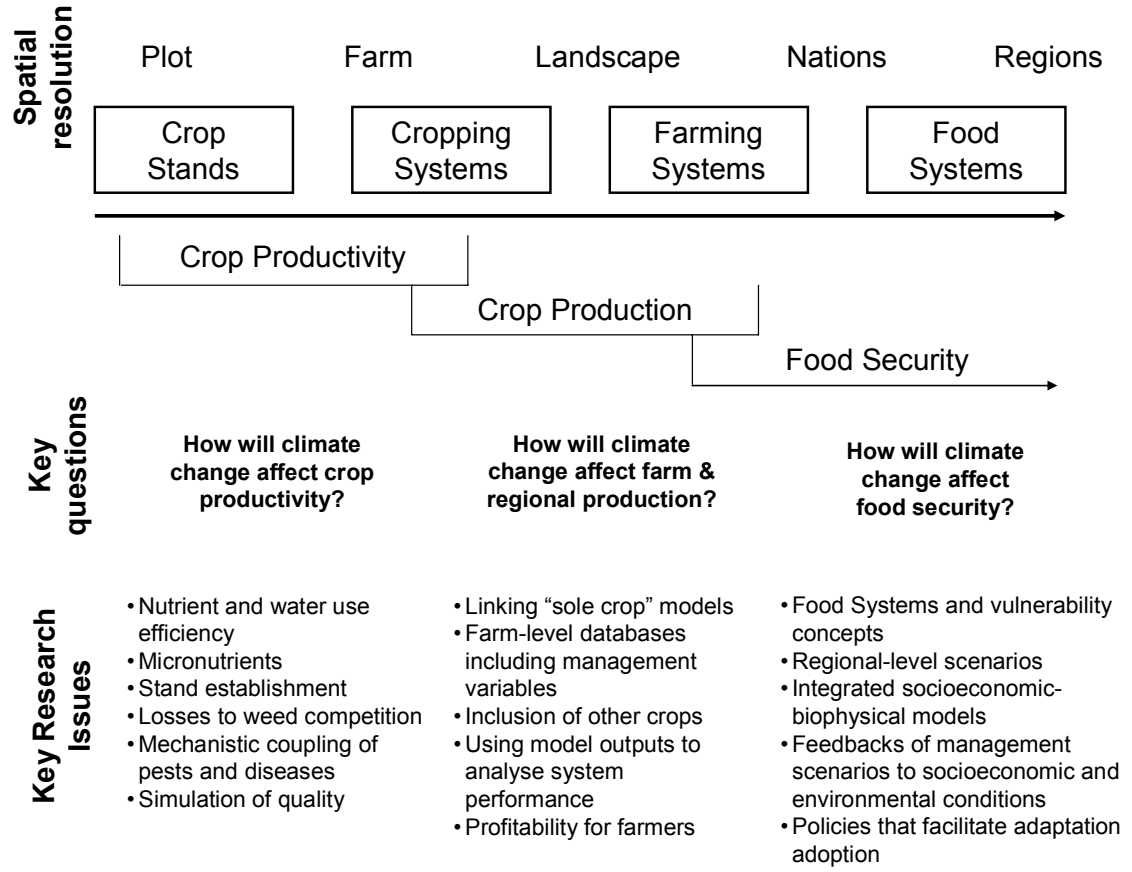


Figure 2. Effects of scale on elements of food systems contributing to food security and the various questions and research issues appropriate to different scales (from Ingram et al. 2008).

In sub-Saharan Africa and parts of Asia the challenges are more daunting. As many people in Africa depend directly on agriculture for their own food security, technological developments could offer options for improving food production at local level (i.e. in farmers' fields). The development of drought- and heat-resistant cultivars is an obvious goal. However, given that substantial research effort over the last few decades has yet to deliver food production systems capable of satisfying needs even under current climatic conditions, and that it typically takes about 10-15 years for new cultivars to progress to become widely distributed, improvements to currently available technologies such as fertilizers are desperately required. Other effective adaptation options in the rest of the food system also require exploration. For example, there are several policy options available when a region is considered as a whole (GEGAFS, 2005). Southern Africa (as for many other parts of Africa) lacks a regional policy framework for coordinated development of a regional food and agricultural production, distribution and trade system which would take advantage of the region's environmental diversity and economic potential (Mano et al., 2007). Several regional trade studies show that free regional trade would significantly enhance regional economic growth and regional food security by eliminating localized climatic and market risks (e.g. IFPRI, 2003). While more effective institutional arrangements would clearly assist, an effective regional food

distribution system of roads and railways is also essential for alleviating food insecurity whenever local production cannot meet demand. Again, the recent food shortages in the inland countries of Zimbabwe, Swaziland, Lesotho, Zambia and Malawi exposed the limited capacity of the region's transport, warehousing and port facilities.

International research programmes

Much work on food security and climate change is currently occurring under the auspices of the research programmes of the International Union of Science particularly the Earth System Science Partnership (ESSP). The ESSP brings together climate scientists from the World Climate Research Programme (WCRP), with social scientists from the International Human Dimensions Programme (IHDP), and a range of scientists from the International Geosphere-Biosphere Programme (IGBP) and DIVERSITAS to study how the earth system is responding to environmental change (including climate change). The ESSP has a small number of joint projects (see Pahl-Wosti, this volume, for details of water), with Global Environmental Change and Food Systems (GECAFS) as its focus on food issues. GECAFS has been a major driver of the food systems approach and has worked collaboratively with the Food and Agriculture Organization, the World Meteorological Office and the Consultative Group on International Agricultural Research (CGIAR).

The goal of GECAFS is to determine strategies to cope with the impacts of global environmental change on food systems and to assess the environmental and socioeconomic consequences of adaptation responses (GECAFS, 2005). The research is focused on three "fundamental questions" of interest to science, development and society:

1) How will global environmental change (GEC) affect the vulnerability of food systems in different regions?

2) How might food systems be adapted to cope with GEC so as to enhance food security?

3) What will be the consequences (feedbacks) of various adaptation options for environmental and socioeconomic conditions?

The scientific research programme consists of projects involving conceptual research on generic aspects of food systems (such as issues of societal vulnerability) together with studies of contrasting regional food systems in the Indo-Gangetic Plain, Southern Africa and the Caribbean.
Together, these projects aim to: i) investigate how GEC will additionally affect food security in different regions and among different socioeconomic groups; ii) determine how different societies and different categories of producers might adapt their food systems to cope with both GEC (and changing demands for food); and iii) assess the environmental and socioeconomic consequences of potential adaptations to food systems designed to cope with GEC and changing demands for food.

The CGIAR has had long-standing programmes of research on improved crops and livelihoods in rural areas and for the last few years has also been investing heavily in climate change related research. The CGIAR consists of a group of countries, foundations and

international and regional organisations that support research in 15 research centres distributed around the world but principally located in the tropics and sub-tropics. The centres work closely with national agricultural research services and with advanced institutions in OECD countries to provide a coordinated mechanism for improving crops and production practices.

Together, the ESSP and CGIAR are developing a major collaborative initiative on climate change, agriculture and food security that aims to bring together national agricultural research and meteorological services, advanced research institutions and the CGIAR institutes to address this crucial topic. The goal of the proposed programme is to overcome the additional threats posed by a changing climate on attaining food security, enhancing livelihoods and improving environmental management. This will be achieved by:

Closing critical gaps in knowledge of how to enhance, and manage the tradeoffs between, food security, livelihood and environmental goals in the face of a changing climate.
Developing and evaluating options for adaptation to a changing climate to inform agricultural development, food security policy and donor investment strategies.

Assisting farmers, policymakers, researchers and donors to continually monitor, assess and adjust their actions in response to a changing climate.

The proposed 10-year programme is still at an early stage of development, but it is anticipated that the research will be structured in such as a way as to first, provide an analytical and diagnostic framework that is grounded in the macro-policy environment, and ensures effective engagement of rural communities and institutional and policy stakeholders; and second, develop and evaluate instruments, technologies, practices and partnerships needed to decrease the vulnerability of food systems and enable them to prosper under a variable and changing climate.

Key research needs

This brief synopsis demonstrates the need for biophysical and socioeconomic research across the whole food system, and at a range of spatial levels, if food insecurity is to be reduced. While climate change may offer opportunities for some, those who are already poor and food insecure may not have the capacity to cope with this additional shock. Research is required that will:

- Permit intensification of crop and animal production in a sustainable manner that reduces contributions to climate and other environmental change
- Encourage adaptation throughout the food system at a range of levels

- Facilitate the development of new institutional arrangements at regional levels that will enhance storage, distribution and trade opportunities to assist in times of local food shortage
- Identify the most suitable spatial level at which adaptation strategies might be implemented for given situations (e.g. local, national or regional)

The role of the EU

Historically, though its Framework Programmes, the EU has provided funding to consortia to engage in projects that have formed elements of the activities of the ESSP, especially the IGBP and WCRP. The EU, through the European Commission, has also been a donor of the CGIAR However, little EU funding has been directed, to date, into the existing international scientific networks concerned with linking issues of food security and GEC. The EU could play a positive role in this area of research by:

- Supporting financially the existing mechanisms for food security research thereby strengthening the research community internationally and especially in the developing world
- Adopting the holistic food systems approach in its research planning and policy considerations, both within Europe and internationally.
- Building on the recently-completed ESF/COST Forward Look "European Food Systems in a Changing World" which mapped out several research priorities for the next decade or so, including the development of integrated scenarios specifically designed for food system analysis.
- Working with EU researchers so that they can continue to make important contributions to food security research and by promoting food systems approaches within major initiatives such as the proposed ESSP-CGIAR collaborative programme.

The effects of a decade of under-funding of agricultural research, especially in African countries, are becoming obvious, and a priority for the EU should be to build effective capacity in partnership with private and public institutions.

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Global challenges and international agricultural research

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Food and agriculture: today's situation

What are the main issues?

In June 2007, the US Senate adopted the new Energy Bill aiming to increase biofuel production from four billion gallons in 2006 to 36 billion by 2022, most of it coming from maize ethanol production. This example indicates the tension created on the agricultural product market by energy requirements. It comes in addition to higher and more diverse food demand from the emerging countries. The need to increase production for demographic or economic reasons has been well documented during the last 10 years and the case made by specialised institutions (FAO, 2007; IFPRI, 2007). For example, urbanisation changes food preferences, i.e. for more animal and horticultural products: if 229 million tonnes of meat were necessary in 2000 to supply the world, 465 million will be needed in 2050 (FAO, 2006; Steinfeld et al., 2006). These campaigns that were aiming at giving priority to agriculture for food reasons have had little impact on development or agriculture policies; agriculture has been mainly associated with natural resources destruction and water and soil pollution. Reduced investment led to a decrease in stocks of cereals and animal products. The tension was boosted by the rapidly growing oil price (von Braun, 2008). The US government subsidizes the farmers to produce crops for energy and a growing part of the maize shifts to ethanol. Fertilizers, pesticides and the transportation of the agricultural products are more expensive. These conditions attract the investors who speculate since 2004 on agricultural commodities. They contribute to increase the volatility of the prices with the risk that the prices fall down if they decide to leave these markets. All these factors contributed to making consumers in food-importing developing countries (mostly all African countries) unable to afford the products on sale. The interplay of the tensions created by energy, food prices (see Fig. 1) and the markets nowadays generates very strong political concern throughout the world. It is the main global challenge that agricultural research must address at international level.

The sanitary crisis caused by the emergence of zoonotic diseases is another important challenge for health and agriculture science. It affects the developing countries, where recent achievements in controlling infectious diseases that disappeared in Europe a hundred years ago (e.g. rinderpest, to be eradicated by 2010) do not preclude other endemic pathologies from becoming prevalent. European livestock is very sensitive to these pathologies when the changes in climatic conditions open the door to vectors that did not use to cross tropical countries' border (de la Rocque et al., 2008; Perry & Sones, 2007). For example, bluetongue affecting cattle and small ruminants in France and the UK has had a significant impact on the meat sector: up to 30% mortality among the sheep contaminated by the virus; the measures taken to isolate livestock prevent, on the one hand, importation of ovine carcasses from the UK and a 25% price increase, and, on the other hand, exports of young animals to Italy, causing losses estimated at €1 billion in France in 2007 (Saegerman et al., 2008).

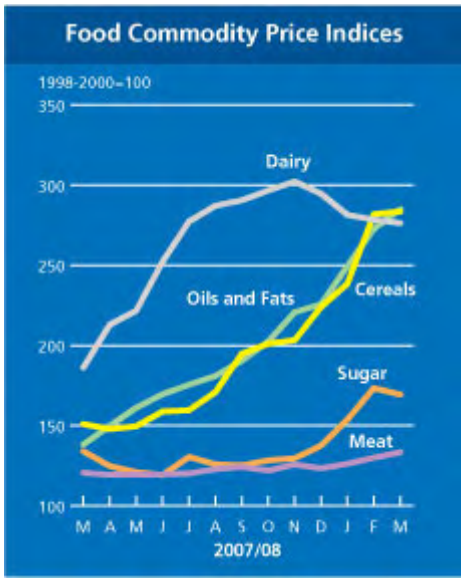

Figure 1: Recent evolution of food commodity prices (source FAO, 2008)

P. Gregory and J. Ingram mentioned in their presentation the impact of climate change.

What are the consequences?

In 2007, farmers responded quite well to the increased demand and higher prices. Cereals production rose by 6% throughout the world, also thanks to favourable weather conditions (with some exceptions like Australia). However, 2007 followed two years of reduced production and world stocks are at their lowest levels (450 million tonnes of cereals predicted in 2008 as against 650 million in 2000). The European Union's milk and meat stocks have disappeared. Cereal yields in Africa have been stagnating for the last 30 years.
Many measures are being taken to increase production. Brazil is extending its arable lands; in September 2007, the Europe Commission abolished the 20-year rule requiring farmers to assign 10% of arable lands to fallows.
The economic consequences are not negative for all stakeholders. European export refunds have not been applied and a part of the CAP budget is available. The exporting emerging countries benefit from the price increases in terms of tax income. By contrast, the governmental budget of the developing countries is seriously affected when they have to cut taxes on imported agricultural products in order to protect their consumers. As for farmers, their income in the industrialised and emerging countries has generally increased after many years of decreasing. The competitiveness of local produce in the South is much better in relation to expensive imported products. As a consequence, the production growth rate of high-value produce (vegetables, fruit, meat, milk) has been much higher in developing countries (2.9%–4% in 2004–2006) than in developed ones (0.2%–0.6%) (IFPRI, 2007). Nevertheless, in developing countries, the situation of family farmers who harvest just for home consumption has been made worse by the higher prices of inputs (fertiliser, mechanic cultivation, pesticides, etc.). Regarding consumers, the urban population of the food-importing developing countries is terribly affected by the food price increases. In the industrialised countries, the part of the household budget devoted to food has decreased by half since the Sixties, but this trend has already changed with the price increases and higher demand for products of better quality.

As regards the scientific community, more attention is being paid to issues that were until recently the preserve of a small category of scientists, experts in "tropical" questions.

The challenges science must address

The situation of food and agriculture in the world is now well documented and regularly reported by the media. It is no longer a concern limited to the population in the developing countries. In both South and North alike, rural and urban communities as well as politicians (Brown, 2008; Chirac, 2008; Diouf and Séverino, 2008) are calling on the scientific community to propose innovations to improve the situation. What are the scientific challenges behind this situation?

A human and social challenge
Lack of food is strictly linked to poverty. Undernutrition and malnutrition result more from lack of resources than from low food production. One of the challenges is therefore to secure the income of the urban poor population. An equally important challenge is to mobilise human farming capacities to feed the world. Today, urban and transboundary migrations are decreasing human farming capacities. This trend would be reversed by creating technical, economic and policy conditions that provide rural communities with a decent income.

An environmental challenge
There is a risk today that the technological pathways that will be developed will be driven by global markets and agricultural outputs. In such a case, the cost in terms of biodiversity, climate changes, food security, sanitary risks and world inequities would be very high. Issues such as greenhouse gas emissions, reduced weather hazards or the impact of climate change on emerging diseases make it necessary for countries in the North and the South to work together on resource uses.

The energy challenge
Tropical conditions have a clear comparative advantage when it comes to agricultural production for bioenergy. The most efficient crops in terms of biomass production for energy are grown in wet climates and hot temperatures. Some of them do not compete with food. Technological solutions must dovetail with local communities' needs, and that also requires some social changes.

Finally, agriculture is called on today simultaneously to feed the world and provide energy for even the poorest while preserving the environment: the combination of these three challenges creates strong tensions; agriculture today is not able to address them at the same time without large changes and research and development investment.

A research agenda to fill the main scientific gaps

These challenges that agriculture is called on to answer lead the scientific community to reshape its agenda. The main international actor, the Consultative Group on International Agricultural Research (CGIAR, 15 centres working in Africa, Latin America, Asia, $ 500 M budget in 2007) did it in 2005 (CGIAR Science Council, 2005). One of the main European actors, the French Agricultural Research Centre for International Development (CIRAD, 800

scientists, more than 40 % being located in tropical regions, € 200 M budget in 2007) recently adopted a new strategic plan (CIRAD, 2007). Most of the regional fora such as the West and Central West and Central African Council for Agricultural Research and Development (CORAF/WECARD) have done it too.
In addition to those mentioned by P. Gregory, some of the proposed research priorities match up more particularly with the evolving challenges and the existing gaps in research agendas.

Invent an ecologically intensive agriculture
The intensification of agriculture has used inputs and transformed natural areas. The alternative option proposed here under this approach is to use the ecological services that biodiversity and biological interactions naturally provide. It requires analysis of the innovation practices adopted by the various stakeholders. The changes proposed in terms of agricultural intensification are based on better knowledge of the ecological process of agro-systems and the social conditions for knowledge adoption (Griffon, 2007).

Anticipate and manage the risks associated with wild and domestic animals
The emergence of zoonotic diseases has been recently facilitated by, among other things, the migration of people and goods, climate change and promiscuity among people and among domestic animals. The knowledge of the links between demography, ecology and epidemiology should be used to define predicting models and customise biotechnology tools to fight against the emergence of such diseases.

Elaborate public policies shaped to reduce poverty and inequities
Local authorities, national governments and development policy-makers need to have a clear vision of the role that agriculture could play to reduce structural inequities and poverty. With rapidly increasing prices, knowledge about how consumers, producers and markets adapt in different policy contexts calls for comparative studies. Combining agronomic and socioeconomic data would help to create models and to design regulations that are appropriate, e. g., to limit price volatility.

Better understand the relations between nature and societies for sustainable management of landscapes
In order to have better knowledge about the interactions between agriculture and ecosystems, it is necessary to analyse the impacts of agriculture, forestry or livestock systems as well as the environmental services they provide. As the interests of the different stakeholders involved in these systems may diverge, analysis of the change process occurring in these systems makes it necessary to combine the natural, life, human and social sciences. Here too, in order to help the decision-makers, models have to be created that combine biophysical functions, human impact and collective decisions at landscape level.

A favourable political context

Until recently, the 850 million undernourished people, the sanitary risks created by the demographic and health conditions of the developing world, the illegal migrations of populations and the energy crisis were the main factors of global political concern. Now the food crisis means that, instead of halving the number of undernourished people by 2015 as adopted during the World Food Summits, 1.2 billion people could be in such a situation at that date. The political context is even rife for reform of the Common Agricultural Policy or

for driving the World Trade Organisation (WTO) Doha Development Round in such a way that market liberalisation is not seen as the only means to help the economy of developing countries highly dependent on agricultural imports. The Bretton Woods institutions and the political leaders share an interest in supporting agricultural policy based on the fact that this sector creates the main economic activities for 2.5 billion rural dwellers and the resources to nourish the poor urban populations who are nowadays taking part in demonstrations all over the world.

Alongside the permanent awareness efforts by the FAO and the IFPRI, and the call to be launched by the G8, the most important initiatives taken recently are:

- The World Bank has focused its 2008 annual report on Agriculture for Development (World Bank, 2007) and analyses what agriculture can do for development.
- The European Commission issued a Communication on Advancing African Agriculture (EC, 2007).
- The African leaders adopted a target of a 6 percent agricultural sector annual growth (NEPAD, 2005).
- The International Assessment of Agricultural Science and Technology for Development (IAASTD, 2008), which delivered its final report on the most promising knowledge, science, technology and policies for agriculture.
- In France, the agricultural research organisations (CIRAD, INRA) launched a prospective exercise to be concluded in June 2008 (called Agrimonde 2050)

All these initiatives stated that interaction between the stakeholders and the scientific community is a unique way of launching the absolutely necessary innovation process in agriculture, notably in order to improve the adoption rate for new technologies. This approach will have to be privileged by the new investments that agricultural research requires for this purpose at national, regional and international levels.

The existing international agricultural research mechanisms

Until the 1980s, the international agricultural research system was shaped by the US universities and foundations which set up and run the CGIAR In Europe, former colonial countries run tropical research centres (French agricultural tropical institutes, ORSTOM, KIT, NRI, IAO, ICCT, etc.). In Africa, countries were building up agricultural research centres from their colonial heritage.

In the 1980s, two main centres emerged in Europe with the Wageningen University and Research Centre (the Netherlands) and in Montpellier (France) with Agropolis, CIRAD, INRA, IRD, Supagro and Universities. The European Commission launched the programme Science and Technology for Development in the first Research and Technological Development Framework Programme (RTD FP 1). In Africa, the structuring and networking of agricultural research were facilitated by the creation of regional agricultural research fora (CORAF, ASARECA, SACCAR) and regional research centres. Most donor agencies supported reinforcement of these national and regional structures.

In the 1990s, the Global Forum for Agricultural Research was created to facilitate dialogue among all agricultural research stakeholders. Regional fora also emerged in Latin America, Asia/Pacific and North Africa/Middle East (see Fig. 2). In Europe, several coordination

initiatives were launched at policy or actor levels: the European Initiative for Agricultural Research for Development, EIARD; the European Forum for Agricultural Research for Development, EFARD; the European Consortium on Agricultural Research for the Tropics, ECART; Natura, a consortium of universities; etc. (see Fig. 3). However, at the same time, in Africa and Latin America structural reforms boosted by the IMF and World Bank, together with the decline in development assistance for agriculture (The World Bank, 2007), strangled the national agricultural research systems, resulting in dramatic staff reductions and insufficient infrastructure investments.

The global picture gives the impression that Agricultural Research for Development is probably the most organised public research sector, perhaps somewhat over-structured.

How do these mechanisms make agricultural research more efficient today?

- These mechanisms facilitate political concertation, in Europe between the Commission and the Members States, in the world between the different stakeholders. The priorities are defined and the research agendas are drawn up in a more inclusive way today.
- The programmatic approach is more open. The concepts of Global Partnership Programmes defined by the Global Forum or Challenge Programmes adopted by the CGIAR in principle allow equal participation of the partners in the research activities.

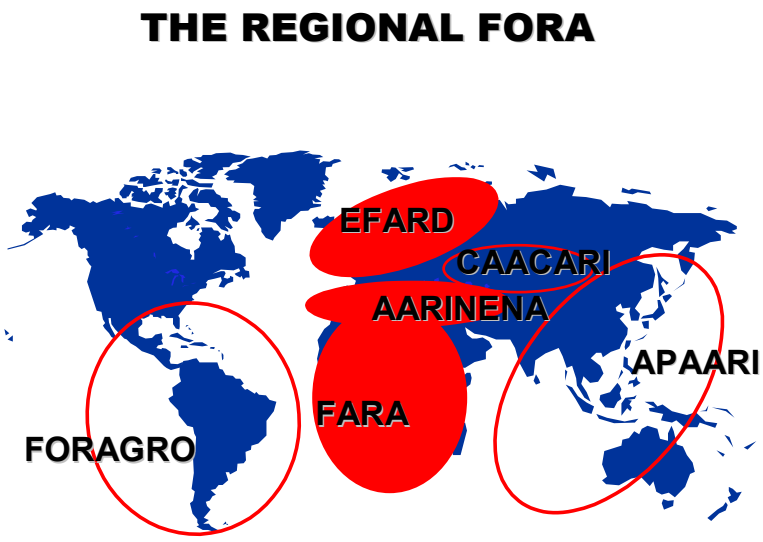

Figure 2: Regional Fora on Agricultural Research for Development (source Hoste, 2006)

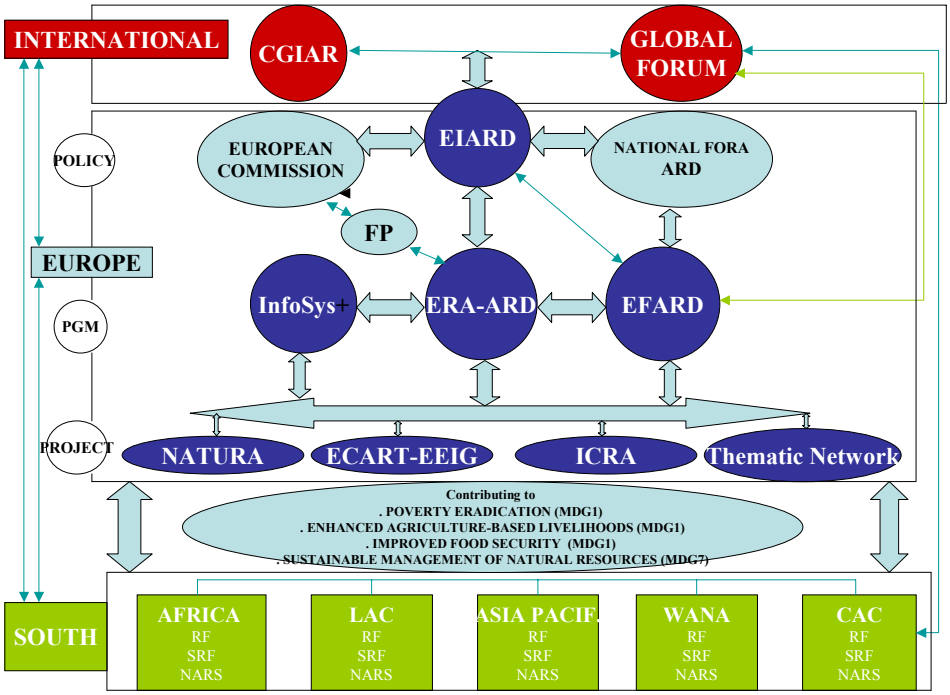

Figure 3: Organisation of agricultural research for development in Europe in terms of the regional and international system (source Hoste, 2006).

- With issues common to North and South agriculture, these mechanisms facilitate joint mobilisation of the best research and agricultural research specifically dedicated to development: for example in France, CIRAD is involving INRA research capacities to questions raised at international level by emerging diseases or policies for forestry sustainable conservation and use. The mapping of the European capacities assigned to international agenda is better known (ERA-ARD, 2007).
- The synergy of the instruments of the different European Community policies is also improved, and complementary actions are defined for common priorities (e.g. DGs DEV and AIDCO with the Food Security Thematic Programme and DG Research with the FP 7 Food, Agriculture, Biotechnology thematic priority).
- Strong national agricultural systems have emerged from middle-income economies like Brazil (Embrapa), China (CAAS) or India (ICAR); they project visions from the South with a strong voice and lead South-South scientific cooperation.

What does not work?

- Investments are not on a par with the political commitment. In 2000, one third of the $37 billion total investment in agricultural research in the world was made by the private sector; 90% of this budget was spent in OECD countries (Pardey et al., 2006). The agricultural research private sector does not invest in developing countries. Combined with very low public investment in RTD, the gap between industrialised and least developed countries in agricultural research is widening.
- Joint programming of international agricultural actions by the European actors is far from being optimal. Synergies are found in EC programme priorities but the selection criteria foster competition. New FP 7 instruments (large-scale instruments, ERA-NET) encourage joint programming at the level of R&D actors or national programmes. The EEIG Ecart is

facilitating strategic discussions on priority areas between its members (CIRAD, IAO, IICT, IRD, NRI and soon INIA). But common investments, bringing together scientists to create the conditions for multidisciplinarity, robust critical mass, impacting on national and regional agricultural R&D capacities at European level, have still to be worked out. The RTD Framework Programme was a pioneer in the field of international cooperation. However, the FP 7 was defined in 2004–2005 when political concern was not as intense as today. Its ambition vis-à-vis international cooperation is very limited, with no overall financial target, a small number of specific international cooperation actions supported, and a budget devoted to agricultural research being one third of that allocated to the health priority.

- The Global Forum for Agricultural Research is not playing its facilitating role sufficiently. Its credibility is based on its initiatives being taken on board by the different stakeholders. Recent changes in its leadership may improve the conditions for better use being made of its mandate.
- The existing competition between the agricultural sectors in Europe and some emerging or neighbouring countries does not facilitate joint knowledge production between scientific communities; some commodities are clearly in competition on the global market.

Proposals for the ERA

The European Union has a role to play in facilitating the innovation process to meet the challenges that agriculture is facing. It can develop a new comprehension of these challenges, shared by a huge diversity of stakeholders, and pinpoint the scientific questions that are behind these challenges. It may encourage integrative approaches, facilitate "de-fragmentation" of the European partners and make compatible the most sophisticated research with access to knowledge for development.

The objectives and conditions of international scientific cooperation have to be clarified. As the results of this international cooperation are expected to impact on countries' social and economic development, these objectives and modalities cannot be the same for Brazil and Burkina Faso. A set of criteria must be defined in order to differentiate the types of countries. They can be based on:

- their comparative advantages in terms of science quality (existing centres of excellence, full reciprocity in opening up R&D programmes to European actors, unique natural resources for joint European and foreign interest, etc.);
- the external policy goals (development goals, such as reducing poverty and inequities, are relevant for developing countries, not as much so for emerging countries; global public goods management is a more appropriate objective with that type of country; full association objective with neighbouring countries, etc.);
- possible interactions with the European agro-farming sector (avoiding scientific cooperation for crops in competition; taking into consideration the interests of the European private sector regarding resources or market access);
- the welfare of European citizens (food safety for non-competing imported products, for example).

These criteria, when combined, constitute a framework that can be applied to each scientific priority in order to select the types of countries which are eligible for European scientific cooperation: industrialised countries, emerging countries, low-income countries, neighbouring countries. It is a tool intended to help the decision-makers involved in the negotiations

between the European Union and third countries or regions. It will clarify the European positions in these programmes vis-à-vis the third countries or regional partners as well as vis-à-vis European society that invests public funds in these programmes.

Mobilisation by the European Union of the existing mechanisms makes it easy to define a common vision of the global challenges faced by agricultural research, and to discuss within Europe and with third countries at regional level the implementation of this vision. ERA-ARD has started this exercise (Jiggins and Poulter, 2007). The criteria framework will help to create win-win conditions for R&D international cooperation and to adopt joint objectives. Combining different DGs of the European Commission with representatives of the Member States will facilitate the synergies between RTD and external policies programmes in the interests of better efficiency.

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ACRONYMS

AARINENA	Association of Agricultural Research Institutions in the Near East & North Africa
APAARI	Asia-Pacific Association of Agricultural Research Institutions
ARD	Agricultural Research for Development
ASARECA	Association for Strategic Agricultural Research in Eastern and Central Africa
CAACARI	Central Asia and the Caucasus Association of Agricultural Research Institutions
CAADP	Comprehensive African Agricultural Development Programme of NEPAD
CAAS	Chinese Academy of Agricultural Sciences
CAP	Common Agricultural Policy
CGIAR	Consultative Group on International Agricultural Research
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement (France)
CORAF/WECARD	Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricole (West and Central African Council for Agricultural Research and Development)
EC	European Commission
EEIG ECART	European Economic Interest Grouping - European Consortium for Agricultural Research in the Tropics
EFARD	European Forum for Agricultural Research for Development
EIARD	European Initiative for Agricultural Research for Development

EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária/Brazilian Agricultural Research Corporation
ERA	European Research Area
ERA-ARD	European Research Area-Agricultural Research for Development
EU	European Union
FAO	Food and Agriculture Organisation
FARA	Forum for Agricultural Research in Africa
FORAGRO	Foro Regional de Investigación y Desarrollo Tecnologico Agropecuario
FP7	7th Research and Technological Development Framework Programme
GFAR	Global Forum on Agricultural Research
IAASTD	International Assessment of Agricultural Science and Technology for Development
IAO	Istituto Agronomico per l'Oltremare (Italy)
ICAR	Indian Council of Agricultural Research
ICRA	International Centre for development oriented Research in Agriculture
IFPRI	International Food Policy Research Institute
IICT	Instituto de Investigação Cientifica Tropical (Portugal)
IMF	International Monetary Fund
INIA	Instituto Nacional de Investigación y Technología Agraria y Alimentaria (Spain)
INRA	Institut national de la recherche agronomique (France)
IRD	Institut de recherche pour le développement (France)
KIT	Royal Tropical Institute (The Netherlands)
LAC	Latin America and the Caribbean
MDGs	Millennium Development Goals
MS	Member State(s)
NARS	National Agricultural Research Systems
NEPAD	New Partnership for Africa's Development
NRI	Natural Resources Institute (Greenwich University, United Kingdom)
ODA	Official Development Assistance
OECD	Organisation for Economic Cooperation and Development
ORSTOM	IRD's previous name
R&D	Research and Development
RTD	Research, Technology Development and Demonstration
SACCAR	Southern Africa Council for Agricultural research
SUPAGRO	Centre international d'études supérieures en sciences agronomiques (Montpellier, France)
UK	United Kingdom
UN	United Nations
WTO	World Trade Organisation

Sustainability in the water sector

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The sustainable management of water resources in times of global change is one of the most pressing challenges of the 21st century. Globally freshwater resources are not (yet) scarce but they are unequally distributed among world regions, but also among countries and different social groups within a river basin. The urgency of the problem is reflected in some figures on key water and sanitation statistics published by the UN programme on Water for Life[1]:

- The world's population, 6.2 billion people in 2002, is expected to increase to approximately 7.2 billion people by 2015. Almost 95 per cent of the increase is expected to be in developing regions.
- Water withdrawals for irrigation have increased by over 60 per cent since 1960. About 70 per cent of all available freshwater is used for irrigation in agriculture. Yet because of inefficient irrigation systems, particularly in developing countries, 60 per cent of this water is lost to evaporation or is returned to rivers and groundwater aquifers.
- Water use increased six-fold during the 20th Century, more than twice the rate of population growth. While water consumption in industrialized countries runs as high as 380 litres/capita/day in the United States and 129 litres/capita/day in Germany, in developing countries 20-30 litres/capita/day are considered enough to meet basic human needs.
- In parts of the United States, China and India, groundwater is being consumed faster than it is being replenished, and groundwater tables are steadily falling. Some rivers, such as the Colorado River in the western United States and the Yellow River in China, often run dry before they reach the sea.
- Freshwater ecosystems have been severely degraded: it is estimated that about half the world's wetlands have been lost, and more than 20 per cent of the world's 10,000 known freshwater species have become extinct, threatened or endangered.

This dire situation is aggravated by the potential impacts of climate change which may even intensify some problems and which introduces another dimension of major uncertainty into the development of sustainable water management regimes. However, water crises have often been caused by problems of governance and inefficient and ineffective management not by resource or technology problems. Correspondingly more and more voices have advocated the need for a radical change, for a paradigm shift in water management. The arguments put forward differ in detail and emphasis but not in the essential elements of the nature of the needed paradigm shift which are (Pahl-Wostl, et al, 2006):

- move towards participatory management and collaborative decision making,
- increased integration of issues and sectors,
- management of problem sources not effects,
- decentralized and more flexible management approaches,
- more attention to management of human behaviour by “soft” measures,
- include environment explicitly in management goals,
- open and shared information sources (including linking science and decision making),
- incorporating iterative learning cycles.

[1] http://www.un.org/waterforlifedecade/factsheet.html

- The paradigm shift in water management may be interpreted as a sign of an increased awareness of complexity and a fundamental change in understanding what management implies which is not only limited to the field of natural resources and water (Pahl-Wostl, 2007). What is evident is the strong emphasis on governance issues.
- Water governance refers to the range of political, social, economic and administrative systems that are in place to regulate development and management of water resources and provisions of water services at different levels of society (UNDP, 2000).
- The evolution in the discourse from "government" to "governance" implies a change in thinking about policy processes. The notion of government as the single decision-making authority, where state authorities exert sovereign control over the people and groups making up civil society, has been widened by the notion of multi-level, polycentric governance where many actors in different institutional settings contribute to policy development and implementation (Mayntz, R., 1998). 'Governance' takes into account the increasing importance of modes of governing, where non-state and private corporate actors and networks participate in the formulation and implementation of public policy or develop policy instruments that co-exist with existing government policy processes. A major challenge is to understand how all these different processes in concert determine certain policy outcomes and how change in governance regimes occurs and what is required to meet the normative principles of good water governance. According to UNDP "good water governance" is characterized by being:
    - Participatory
    - Consensus oriented
    - Accountable
    - Transparent
    - Responsive
    - Effective and efficient
    - Equitable and inclusive
    - Follows the rule of law

Another important aspect is the increasing awareness that water is a global issue. Water problems have traditionally been considered to be local or regional problems. However, there are strong arguments to take the global dimension into account (Pahl-Wostl, et al, in press; Alcamo et al, 2008). First, the hydrological system is a global system and exchange processes occur at global level over relevant time periods (e.g. climate change impacts; other teleconnections for instance between deforestation and precipitation). Second, global environmental change (GEC) and socio-economic phenomena at the global level increasingly create situations in which the driving forces behind water related problems and conflicts lie outside the reach of local, national or basin oriented governance regimes (e.g. global trade impacts on water quantity and quality). Third, many local phenomena occur globally such as erosion, eutrophication, urbanisation, biodiversity loss, or the introduction of invasive species. The same is valid for many human health issues like the poor quality of drinking water supply and of sanitation in poor countries. Such local phenomena may imply alarming global trends, e.g. the construction of dams led to a fragmentation and flow alteration of the world's river basins with major and sometimes irreversible impacts on associated freshwater ecosystems (Nilsson et al, 2005). Furthermore, lessons learnt in one part of the world, could be useful and relevant for other parts of the world and comparative learning justifies a global approach.
Unfortunately dealing with water issues was often linked to technological or institutional panaceas. What is needed is what can be called a "diagnostic" approach which develops tools

to analyse problems embedded in context and supports the development of context specific integrated solution instead of advocating simplistic panaceas.

Existing international cooperation mechanisms

International S&T coordination and the link to international policy processes are quite fragmented and weak. This can be attributed on one hand to the absence of a coordinated international policy process on water issues. On the other hand the scientific community is quite fragmented which does not really support integrated and systemic approaches to analyse, understand and manage water resource and capacity building. Pahl-Wostl et al (in press) analysed the current state and possible future developments of global water governance. The following overview on major players and initiatives to coordinate international cooperation is derived from this paper:

The World Water Council and World Water Forum

In 1996, the World Water Council, an international multi-stakeholder platform, was established to address critical water issues at a global scale. The Council organises the World Water Forum, which constitutes the major global forum on water issues. Although this operates at global level, it is not strictly speaking a centralized UN activity. Linked to the forum is a ministerial conference of nation states that produces a ministerial declaration, albeit without binding commitments. Such forums in combination with ministerial meetings have not produced strong and binding statements and are seen as ineffective (Gleick and Lane, 2005). Conflicting interests have influenced wording, content and outcomes of these declarations. The proposed alternative of smaller, focused ministerial meetings coordinated by the United Nations might be more effective and better linked to Ministers of Finance or Economic Planning, but they may be less legitimate.

UN agencies, programmes, mechanisms, and institutions

UN agencies (e.g. FAO, UNESCO, WHO, World Bank), funds (e.g. Global Environment Facility) and programmes (e.g. UNDP, UNEP) are active in the water field in manifold ways. In 2003, UN Water was established as an umbrella mechanism to coordinate UN activities on the follow-up from the World Summit on Sustainable Development (WSSD) in 2002 and the Millennium Development Goals (MDGs). Among those goals is MDG 10 that aims to cut in half the proportion of people without sustainable access to safe drinking water and basic sanitation. Sound water resources management and development is a key to achieving all of the MDGs. The non-binding, global, centralized, Millenium Declaration has mobilized major actors to develop activities (e.g. UN Millennium Project) to promote action to achieve the MDGs. The UN Millennium Project's task force on water developed an action plan (UN Millenium Project, 2005) and unanimously concluded that the water and sanitation target will not be reached without global leadership and cooperation to mobilize the necessary resources. In 2005, the UN launched the 'Water for Life' decade (2005-2015) in order to support the implementation of the MDGs on water supply and sanitation as well as to strengthen the capacities of member states for good water governance, cooperation, management, sustainable use and protection of water resources. There are activities which are partly endorsed by UN

Water, like the UNESCO-led World Water Assessment Programme (WWAP), which since 2003 publishes in triannual intervals the World Water Development Report (WWDR). Others are fully under the aegis of one UN body (e.g. UNESCO's International Hydrological Programme - IHP) or jointly led by two or more bodies (e.g. UNEP's and GEF's Global International Waters Assessment – GIWA, which meanwhile is completed). It can be concluded that the UN does not speak with one voice about water issues and that the different voices are not necessarily well orchestrated.

Global scientific and professional communities

Global communities of scientists and water professionals increasingly shape the international debate on water issues. The International Law Association has been active in this field since 1873 and more than 30 years ago UNESCO-IHP (the International Hydrological Programme) set up its own scientific programme. At present, the diverse epistemic community includes the Global Water Partnership, the International Water Association, the International Water Resources Association, the International Network of Basin Organizations, the Global Water System Project, the UNESCO-IHE Institute for Water Education and many others. However, unlike in other fields of research like climate change, this epistemic community neither has a formal political mandate, nor does it provide advice through formal channels to the governance process. An interesting development for international scientific collaboration is the Joint Projects of the ESSP (Earth System Science Partnership) of the Global Change research programs. The current themes addressed are carbon, water, food and health. The aim of the Joint Projects is to build a global environmental change (GEC)-oriented research agenda of direct relevance for societies. They have a strong community and capacity building component. Given the fact that the ESSP is an activity of the scientific community it could establish itself as a strong voice not driven by political interests. Box 1 summarizes some information on the Global Water System Project that is currently building up its activities with a strong emphasis on the global dimension of water problems.

The Global Water System Project

The Global Water System Project (GWSP) is a joint project of the Earth System Science Partnership (ESSP) consisting of four Global Environmental Change Programmes: the International Geosphere Biosphere Programme (IGBP), the International Human Dimensions Programme (IHDP), the World Climate Research Programme (WCRP), and DIVERSITAS, an international programme of biodiversity sciences. The *overarching question* of the GWSP is how human actions are changing the global water system and what are the environmental and socio-economic feedbacks arising from the anthropogenic changes in the global water system. *Three core questions* follow from this overarching question, and these questions make up the three major research themes of the GWSP:

What are the magnitudes of anthropogenic and environmental changes in the global water system and what are the key mechanisms by which they are induced?

What are the main linkages and feedbacks within the Earth system, arising from changes in the global water system?

How resilient and adaptable is the global water system to change, and what are sustainable management strategies?'

Activities

Major product-oriented activities in the first phase since 2005 include: the development of a digital world water atlas; the development of water indicators for use in assessment and science applications; improved estimates of the world water balance; the compilation of a Global Water System lexicon; the organisation of a workshop on key issues of the global governance of water; joint activities with the LOICZ (Land Ocean Interactions in the Coastal Zone) project, such as a study of the impact of land use change, in particular mega-city growth, on coastal processes; the organisation of an advanced educational institute for regional and global water researchers; a baseline study on environmental flows; regional case studies conducted in cooperation with other initiatives, the development of a global database on dams and reservoirs to the development of curricula and capacity building activities in the field of adaptive water management.

Global Initiatives

GWSP defined three Global Initiatives as Integrative Study Areas (ISA) within which the implementation of the tasks of the Scientific Framework will be coordinated and the delivery of truly integrated and interdisciplinary research results will be secured. The Initiatives are targeted towards the production of scientifically outstanding and highly policy-relevant results. The three Global Initiatives are:

Global Scale Initiative: Ranking of Changes to the Global Water System

Global Catchment Initiative: Bringing the Global Perspective to River Basin Research and Management

Global Water Needs Initiative: Balancing Human and Nature Water Requirements

For further information contact the GWSP IPO: www.gwsp.org, gwsp.ipo@uni-bonn.de

EU Activities

EU policical programmes – the European Water Initiative

The European Water Initiative (EUWI) was launched at the Johannesburg Summit in 2002. It states that the EU will contribute to achieve MDG 10 and to establish national integrated water resources management plans by 2005. The main focus of the Water Initiative is to reinforce political will and commitment to action, promote improved water governance, capacity-building and awareness, improve the efficiency and effectiveness of water management through multi-stakeholder dialogue and coordination, strengthen coordination through promoting river basin approaches, and identify additional financial resources and mechanisms to ensure sustainable financing. Despite its promising start the EUWI falls short of achieving its stated goals at least in quantitative terms. Despite of quite successful networking activities it has not been possible to mobilize major additional financial resources for its implementation.

EU funded international research collaborations

The EU framework programs have a long tradition in funding international research cooperation. Whereas there was a clear separation between thematic research programs and the INCO (International Cooperation) program in the 4th and 5th EU Framework Programs the

6th Framework program encouraged to include international cooperation as well in the thematic research priorities to promote a better science and technology transfer. It is too early to evaluate if this change in funding policy has resulted in the expected increase in the effectiveness of international exchange in S&T transfer in the water sector. The new programs have definitely strengthened the exchange among research communities that had been quite separate before.
In order to evaluate the success of its water related research projects funded under the INCO programme, the European Commission asked an international panel for a critical review. The major results from an evaluation of 77 research projects related to IWRM funded under the 4th, 5th and 6th European Framework Programme are (European Commission, 2006) are:

- The programs have been successful in promoting integration across disciplines and in engaging stakeholders.
- There is a lack of awareness of the political nature of IWRM.
- The approaches relying on scientific and economic arguments and rationality are in contrast with political reality.

The following recommendations were made:

- The programs should promote a constructively engaged research approach.
- Projects should be aligned more strongly with regional priorities.
- Research programs and the associated networking activities should connect local knowledge, socio-economic development cultures and policy institutions and implementing bodies.

Some conclusions can be drawn regarding the current potential and limitations of EU activities in the water field:

Strengths

- European research is leading in interdisciplinary approaches. It has established a strong and worldwide unique expertise on human dimensions research in the water field.
- The EU has a reasonably well functioning science-policy interface compared to other countries.
- EU water policy is characterized by innovative legislative frameworks such as the European Water Framework Directive.
- The integration of international cooperation in thematic areas of the framework program is a step towards overcoming the traditional fragmentation and lack of exchange in the research community.

Limitations:

- It is difficult to build up long-term activities crucial for efficient and effective international S&T cooperation due to the limited duration of the framework programs and thus individual projects. National research projects in this area run for a duration of 6-10 year. This is required to lead from research to implementation. In the EU such a direct continuity is not foreseen. It may be established be researchers participating in sequential research activities.

- This lack in continuity is also not compensated in the policy arena due to a lack of coordination of international cooperation in international policy
- Correspondingly there is no long-term support of products such as knowledge systems or tool boxes. However, continued long-term support is often a condition for innovative products to be adopted by practitioners (e.g. decision support systems or open information systems such as the online tool-box of the Global Water Partnership on IWRM).

This lack in continuity renders European research programs far less effective than they could be given the substantial financial resources and the innovative potential of the research pursued.

The role of the EU to strengthen international cooperation to deal with emerging global water crises

The EU could and should play a more important and visible role in international water research and governance as a key player in the international policy arena and as a funding body of cutting edge research that provides the foundations for sustainable water resources management. To achieve this goal the following recommendations are made regarding the topics to be addressed and the structural changes to be implemented:

Important topics where international S&T is mandatory and the EU could play a leading role:

- More leadership is required in the global governance of water.
- Building on its expertise and achievements, the EU should take a leading role in supporting a transition towards more adaptive and integrated water management approaches – urgently needed for sustainable water management in times of global and climate change.
- More efforts need to be devoted to develop a diagnostic approach which develops tools to analyse problems embedded in context and supports the development of context specific solution instead of advocating simplistic panaceas. This requires international comparative studies and global data bases.
- A thematic area of key importance is multi-level and cross-sectoral adaptation to climate change to increase adaptive capacity and reduce vulnerabilities. Here strong leadership is required in both research and policy.
- Capacity building is a key necessity to develop the skills required to further develop and implement innovative approaches in the water field.

Changes in structure where the EU could play a leading role:

- The EU could generate synergies by a stronger collaboration with and support of international scientific networks. Here the global change programs are of specific interest since they are science driven and have no own political agenda.
- There exist very few mechanisms for funding global research projects urgently needed to develop a global knowledge base and strengthen the research community in the water field.
- The international research community in the social sciences working on water issues is yet weak and fragmented. Efforts and resource must be devoted to strengthen this community to meet the increasing demands of social science expertise in research and implementation.

- To be effective the EU Commission must establish structures for a long-term support of international research projects including stakeholder involvement. This would also improve the link between research and implementation.
- There is an urgent need to develop a long-term strategy for international cooperation at EU level (including priority areas, topics, networks) and a coordination of fragmented activities.

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Broader perspectives

Energy and Climate Change in the EU. The Role of Science and its Limitations

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1) Do we have today a shared narrative for Science and Technology?

In 2001 John Brockman invited 25 of the most prominent world personalities in almost every relevant field of scientific research to share their thoughts about the overall prospects of development in science and technology for the next fifty years (Brockman, 2002).

The contributions were aimed for the general public and written in a language that made sense even for readers without scientific background. The outcome was a splendid and inspiring book which, however, clearly shows the lack of a shared narrative framework for science and technology today. Instead of a common understanding of hopes and needs for science and technology, we witness separate and fragmentary statements, enthusiastically engaged in specific institutions, methodologies and "research cultures". Among the different writers contributing for the Brockman's project, excitement overcomes by far some more grim and critical prospects. New rapid expansive fields of research like biotechnology, nanotechnology or artificial intelligence offer the best example of extreme promethean enthusiasm regarding endless possibilities to improve the quality of human life.

Pluralism as a category describing the reigning status in science and technology today wasn't the result of sheer postmodernism concepts, transferred from philosophy or literature to the realm of epistemology and to the study of science as a complex and sustained societal experiment. On the contrary, pluralism reflects a long trend in the history of science and technology, namely the loss of a common "world vision" (Weltanschaaung). The ideal of the "unity of science" remains today more like a moral reminiscence, still kept in some domains of basic teaching in science curricula at graduation level, than as a guidance value for interdisciplinary dialogue and even cooperation.

To address science and technology issues as a matter of public policy, both at national and European Union levels implies the understanding of the wide range of consequences deriving from the pluralistic features that are hegemonic in the field of technological and scientific research. We shouldn't expect that the direct actors of the technologic and scientific process should be in suitable conditions to give the more balanced and accurate advice in order to frame the best policy framework. More likely, direct actors will tend to emphasize the specific needs of their fields and demands of the research communities in which they are engaged. Both as individuals and as members of S&T institutions, they will tend to voice their interests, and to identify those interests with supposed global priorities. And this confusion between particular interests and broader needs is facilitated by the lack of a common vision regarding the future of society and the role of Science and Technology (S&T) in its fulfilment.

2) Which criteria would be most suitable to frame science & technology public policies?

The issues of International Science and Technology Cooperation are under the label of public policy at least from two different perspectives. First, they define goals for public spending (that can be escorted also by private funding, namely from the non-profit sector and Foundations) in S&T activities. Secondly, they are subordinate to evaluations in the realm of foreign policy. In the case of the European Union the situation is even more complex, given the fact that this domain is a shared competence between the Union and the Member-States, implying a considerable effort of dialogue and harmonisation on criteria, methods, targets and different types of instruments, namely financial ones.

The information filtered from experts and direct actors on science and technological activities is an essential step in the complex process of policy framing, although the evident (and less visible) limitations of its scope, given the pluralistic and fragmentary status of current research communities and institutions, as mentioned above. There is no such thing as S&T cooperation without the contribution of the scientific community, as there is no warfare without the involvement of armed forces. However, neither the military nor the scientists are more entitled to define the strategic or the science & technology policies, than those political institutions that have sufficient legitimacy to perform that task on behalf of the community and in representation of the public good.

The core of public policy is the selection of priorities. So, the right question for international S&T Cooperation is about the best ways of choosing priorities.

I would like to suggest the following criteria to facilitate the mission of setting priorities:

- Priorities should reflect critical and crosscutting areas and domains. They should tackle issues with a teleological (or finalist) intrinsic feature in order to find positive solutions to problems, affecting the engine of society and undermining its peaceful progress.
- Priorities should be considered as a challenge deserving attention from every epistemological perspective, urging multidisciplinary cooperation and cross-fertilisation. They should encourage networking and an efficient organization of skills and competences in multinational, pan-European and trans-European projects.
- Priorities need to be coherent with the overarching goals of European Union policies. They should establish synergetic connections with them, deepening simultaneously the knowledge basis where they are grounded.
- Priorities should be able to provide services of universal value, reinforcing the global trust in the European Union as a benign and peaceful actor in the international system.

3) Why should the energy and climate change domains rank among the top priorities for international science & technology cooperation?

It's virtually impossible to find another global subject that fits so dramatically well within the grid of the criteria suggested above.

Climate change is *the* teleological issue of our century (at least). It reflects a global tipping point, in which humankind did already cross the hidden red line that separates *using* nature

and ecosystems from *reshaping* nature and ecosystems in a way that nobody is in condition to foreseen with even a low degree of certainty.

The severity of climate change in the long run was reinforced in the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report (2007). Before that crucial research outcome from the most complex scientific network ever established in world history, the alarm of climate change rang already through the works of Sir Nicholas Stern (*The Economics of Climate Change*, 2006) and Al Gore (*An Inconvenient Truth*, 2006). Sir Stern focused on climate change under the perspective of economics, and his major conclusion was received by many as terrible and unexpected bad news: "Climate change is the greatest market failure the world has ever seen, and interacts with other market imperfections." On the other hand, the former Vice-President of the United Sates, Al Gore, launched a personal crusade around the world, using a book and a movie as weapons, underlining the global danger for the global human society and the Earth as a whole deriving from climate change, which he named, sound and clear as "the planetary emergency of global warming." Besides Stern and Gore we may identify a prolific set of works combining energy, environment and societal decline and collapse, elaborating from different angles the darker sides of our human prospect under the shade of the global environmental crisis (Brown, 2003; Diamond, 2004; Heinberg, 2003 and 2004; Kunstler, 2005; Lovelock, 2007).

Climate change risks the inner structures of the international system fabric, and puts a real danger to a fair balance among nations and to social cohesion within countries. Being a global environmental threat, climate change acts at the same time as a trigging factor to overall strategic instability. According to a study of the British Ministry of Defence, climate change ranks as the first of "three pervasive Ring Road Issues, followed immediately by "globalization" and by "global inequality" (UK Ministry of Defence, 2007). In the same line of thought, the German Advisory Council on Global Change alerted to the conflict potential contained in a feeble or faulted climate protection policy: "If climate protection policy fails and these efforts are not made, it is likely that from the mid 21st century local and regional conflicts will proliferate and the international system will be destabilized, threatening global economic development and completely overstreching global governance structures.", (WBGU, 2007).

Shifting from diagnosis to therapy, we may witness that the European Union role lies in the current international landscape as the unchallenged champion of the need to fight seriously against climate change. Since the March 2007 European Council, the Union has a long run strategy, both inwards and outwards. The EU decided to combine energy policies (the major cause in the human induced climate change process) and climate policies in order to reach a long set of strategic goals. They comprise both internal and external aims and targets. They envision fostering a kind of "ecological modernisation", shifting ways of production, selling and consumption of energy, helped by the strength of leadership through example to bring together the world community, including the United States, and rapid emerging economies like China, India and Brazil to a new international climate protection regime, avoiding a chaotic gap, or an inefficient puzzle of unilateral national or regional targets after the end of the Kyoto Protocol timeframe (2008-2012).

The rationale for the EU to combine energy and climate change policies is based on:

- Environmental reasons.
- Strategic reasons: autonomy, self-reliance, influence in world system, capacity of initiative.

- Security reasons: avoiding insecurity of supply, preventing scarcity and conflict[1].

4) What are the main obstacles we have to overcome in order to have adequate international science & technology cooperation?

Climate change is now again in the first pages of the mass media. However, the intensive media coverage of issues connected with our changing planet only puts more emphasis on the sharp difference between public voicing of concern and really steps done in the right direction of greenhouse gases mitigation and strong adaptation measures.

According to a recent report from the International Energy Agency (IEA) the situation of global investment in new and/or alternative sources and modes of energy production is rather disappointing, taking into consideration the grim scenarios for the next quarter of century: "Given the scale of the energy challenge facing the world, a substantial increase is called for in public and private funding for energy technology research, development and demonstration, which remains well below levels reached in the early 1980s (International Energy Agency, 2007: 52)".

How can we explain this deep gap between our explicit vision of the world (its trends and problems) and the lack of adequate action, namely at the scientific and technological level? We need to bear in mind that science as a societal process is driven by many strong non-cognitive forces: financing constraints; personal narratives and expectations; vested interests; political agendas. From its birth in Modern Ages, science was asked to produce technical operational solutions to marketplace oriented demands. Embedded in the *a priori* optimism of Founding Fathers like Bacon and Descartes, science was organised as an hedonistic enterprise, aimed to provide useful services, comfort for consumers, increase of power for States, added value for shareholders, neglecting the need to take into consideration "small details" and "externalities", like those connected with environmental damage and human health risk. The need for a strong and legally binding precautionary principle lies, precisely, in

[1] In a summary view, the aims of the EU, concerning the Energy and Climate Change strategy are the following:

- Post Kyoto targets for 2020:
  - Reduction of 30% GHG emissions by developed countries in comparison to 1990 levels.
  - Endorse already now an EU commitment to achieve, in any event, at least a 20% reduction of GHG by 2020 compared to 1990
- Internal Electricity and Gas Markets:
  - Ownership unbundling: to separate supply/generation interests from network companies.
  - A European Network of independent regulators [ERGEG].
- Energy Efficiency and renewable goals:
  - Endorse the objective of saving 20% of the EU's energy consumption in a cost-efficiency manner by 2020 as presented in the Commission Energy Efficiency Action Plan.
  - Endorse the binding targets of 20% for the share of renewable energy in overall EU energy consumption by 2020 and 10% minimum biofuels.
- Scientific framework and objective data
  - To avoid an increase of global temperature beyond 2ºC, above pre-industrial age.

the trend for neglecting costs and risks located in the heart of scientific and technological research (Gee, 2001).

Neither the specific scientific agendas nor the immediate marketplace needs are in position to supply the sufficient impetus to put science in the right track to face major challenges. Historically speaking "big science" projects are a kind of a State driven monopoly, as illustrated by the two more visible American examples of the 1940s (the Manhattan Project) and the 1960s ("the race to the Moon" project). To give a prominent degree of priority to energy and climate change as priority fields for international scientific and technological effective cooperation will imply also the need to understand that around the world we find, even within the realm of science and technology communities, different sets of values and rather diverse cultural landscapes. The first obstacle to remove, if the international cooperation is to become successful, is to get rid from the illusion of consensus. "Climate change", still today, receive a different semantic context, according to the diversity of political, cultural and societal frameworks. A well structured and better managed international cooperation scheme, pulling forces and skills together, will be the result of a long and strenuous process, not the beginning of it.

5) What is the job to be done?

If we wish to use a short slogan, we could say that the huge task ahead of us lies in the aptitude to find the narrow window of opportunity that will allow humankind to shift from a TAU (Technology as Usual) model to a ATP (Accelerated Technology Path) model (Richels and Blanford, 2007).

In a sheer list of things-to-be-done this job could appear like this:

- Filling the gaps in crucial information on the Earth System (global).
- To raise awareness and promote capacity building (global). The Interface between science and society, if a reasonable degree of social mobilisation and political legitimacy is to be achieved, remains absolutely crucial (Pereira, Vaz and Togneli, 2006).
- To integrate energy/climate change in a more realistic and less *Realpolitik* driven model of international relations (e.g. with USA).
- To improve cap-and-trade mechanisms after 2012 (Kyoto countries and USA, Australia).
- Development of clean technologies, renewable sources, CCS (Carbon Capture and Storage) (e.g. China and India). This area is deemed crucial, as we may see in recent documents published by the European Commission.
- Promoting energy efficiency (global).
- Integrating adaptation in land use management and urban development (global).
- Adapting Biodiversity policies to Climate Change (e.g. Brazil and many Least Developed Countries).

The enunciation is far from being exhaustive. Many of the most difficult issues are hidden in the preparatory work that needs to be performed in order to achieve the minimal requisites to even approach the possibility of managing those tasks. An example: how are we getting to dialogue on an effective basis with China, when the level of scientific cooperation, channelled through universities is extraordinary low, when compared with the dense cooperation between Chinese and American academic and research institutions?

Two remarks are, however, decisive to put the tasks of international science and technology cooperation in its right context. The first one reminds us of the urgency and severity of the challenges that we are facing. The crossroads of a true "ingenuity gap", to take a famous formula from Thomas Homer-Dixon: "We are indeed in a race between hard imaginative thinking – or what I call ingenuity – and the ever expanding complications of our world. And in too many critical places, and on too many critical issues we're losing the race" (Homer-Dixon, 2003). The second one, echoes in our own intellectual tradition as Europeans. Being a task of public policy, international cooperation in science and technology should, nevertheless, be able to maintain effective boundaries between politics and the core of science (the search of "factual truth"). Quoting Hannah Arendt: "And it is only by respecting its own borders that this realm [political sphere], where we are free to act and to change, can remain intact, preserving its integrity and keeping its promises. Conceptually, we may call truth what we cannot change; metaphorically, it is the ground on which we stand and the sky that stretches above us." (Arendt, 1993: 263-4), Indeed, if science is going to help humanity in this crucial transition towards survival through a more sustainable way of life, we will need to keep open the doors and windows of free criticism, in order to timely evaluate the steps done, correcting mistakes and improving the right achievements.

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Responding to Global Challenges: Re-thinking public economics and finance

Proposal for an international research project of the European commission

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Abstract

The list of global challenges is long, and perhaps, still lengthening, including diverse issues like global climate change, communicable disease control, averting excessive financial volatility, fighting international terrorism, or promoting harmonization of norms and standards across national borders. Many of these issues have properties of a public good. They constitute global public goods; and thus belong to the discipline of public economics and finance. However, the present standard public economics and finance theory is, for the most part, still based on the assumption of a single, closed economy, unable to capture all dimensions of global challenges, notably the dimensions distinguishing them from purely national public goods. Thus, it seems desirable to revisit the current standard theory and explore possible revisions—a (re)design of public economics and finance for the present age of globalization. This paper identifies issues that might require study and debate in this context. It suggests that the required research and reviews would best be undertaken as a cooperative effort of scholars from different parts of the world; and that the European Commission would be well poised to initiate and support such a process.

Introduction

We live in a rapidly globalizing world. New global opportunities are emerging, promising enhanced well-being and prosperity. The Internet is an example. But we also face new challenges and crises. Global warming is an imminent threat; episodes of excessive financial volatility are repeatedly undermining global economic growth and development; and openness of national borders allows "bads" to spread with ever greater ease and speed from country to country—diseases, pollution, crime, and violence.

The list of global challenges confronting policymakers is long, and still lengthening. They figure prominently on national and international policy agendas; and a rapidly proliferating literature exists in most global-issue areas, offering analyses of current trends as well as possible policy responses to particular global issues.

In contrast to the issue-specific debates and literatures on global challenges, standard public economics and finance (PEF) theory has, to date, not been revised to take globalization into account. Most PEF textbooks are still based on the assumption of a single, closed economy. This assumption is increasingly at odds with reality, because the former divide between domestic and foreign policy has become blurred. Many policy challenges today require concerted action at the national level as well as at the international level—a global

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intervention. Yet current PEF theory captures at best the domestic part of global issues. The international facets of these concerns usually remain outside of its focus. They are left to other disciplines, notably international relations scholars to address. As a result, today's understanding of global issues and global policymaking is highly fractured, incomplete, and probably, distorted. This may contribute to challenges remaining unresolved, with some even taking on crisis proportions like the energy and climate change issues.

Moreover, the expanding sub-fields of PEF like global health or environmental economics draw for their economic analyses on current standard PEF theory. Therefore, what they say about meeting global challenges may also often be limited.

Considering the growing importance of global challenges, it would, thus, seem desirable to revisit standard PEF theory and explore how to widen its focus to take account globalization and today's policy interdependence among countries.

This paper develops a proposal for such an expansion of PEF theory. Section I identifies topics that might warrant study and debate in this context. Section II suggests that the revision process itself would best be organized as an international process, based on a global network of PEF scholars. This could facilitate bringing out what is really new and different in today's era of globalization and of utmost relevance to PEF—the changed logic of international cooperation.

Today's national or regional welfare is often best improved not through the conventional approach of *competitive* international relations, i.e. a narrow pursuit of national or regional self-interest. Rather, policy interdependence now calls for a truly *cooperative* approach to international relations, recognizing that under conditions of openness collective action must succeed, lest one's own welfare and wellbeing suffer; and that it will do so only, if it provides significant and fair benefits for all.

Given Europe's historical contribution to the development of PEF theory for the national context, and more recently, its rich experience with analyzing and addressing regional public-policy issues, European researchers and the European Commission (EC) would be well poised to play a special, pro-active role in fostering the creation of such a global network of PEF scholars.

I REVISITING PUBLIC ECONOMICS AND FINANCE FROM THE PERSPECTIVE OF GLOBALIZATION: POSSIBLE RESEARCH TOPICS

As Musgrave and Musgrave (1989) point out, PEF theory has never stood still. When realities, and with them, PEF policy practices have changed, PEF theory usually followed suit. It has also done so in response to the added emphasis placed since the 1980s on privatization. Most PEF textbooks now discuss aspects of public-private partnering.

Experience suggests that actual policy practice of PEF tends to change first, with PEF theory following suit, when policy innovations move into the policy mainstream. Studies (e.g. Kaul and Conceição 2006) show that, in actual practice, PEF already responded to greater openness of national borders. However, as a recent survey of PEF textbooks (Sidikou-Sow 2005) shows, with few exceptions only, the standard PEF theory is still based on the assumption of a

single, closed economy. The challenge now is for theory to catch up with this new, and certainly, still evolving policy practice.

The following list of topics illustrates the types of topics that might warrant review and study in this context. It shows that the required re-thinking could be far-reaching and fundamental. But it also suggests that a PEF theory for global challenges could provide a new framework for understanding international cooperation, pointing towards new avenues of promoting more balanced, sustainable globalization.[1]

1) Expanding the concept of public goods to include global public goods

According to standard PEF theory a rationale for potentially desirable intervention of governments into the economy is market failure; and one of the conditions that may cause market failure is the existence of public goods. Thus, public goods are at the core of PEF theory.[2]

In their pure form, public goods have two main properties: nonrivalry in consumption and nonexcludability of their costs and benefits.[3] Once they exist, they may affect all, in a positive or negative way, with greater or lesser intensity. That public goods are public in consumption explains why many of these goods are underprovided. Individual actors do not reveal their true preferences for these goods; they hope that others will step forward produce and pay for a public good so that they can benefit from the good, when it is available, for free. In this way, individual actors can "save" their own resources for paying for private, excludable goods—and thus maximize their utility.

Such collective action problems are often the fact that prompts state intervention in public goods provision and has led to governments holding unique coercive powers like those of taxation or punishment for noncompliance with established rules and procedures. Today, of course, private actors play an increasing role in public good provision, including in the provision of such services as policing, mail delivery or border control. This is, however, under government contract or regulated and supervised by governments, i.e. in one or the other form of public-private partnering.

Yet the key determinant of whether a good is public or private is not how and by whom it is produced and financed, but rather the nature of its consumption properties—whether it is in the public domain, i.e. nonexcludable, and there for all, i.e. nonrival in its use or consumption.

The consumption properties of public goods have different range—local, national, or transnational, i.e. regional and worldwide or global. Some public goods have always been global. The greenhouse gases are a case in point. When they rise into the air, they enter—and progressively burden—the atmosphere, with potentially negative consequences for all. Yet

[1] For a more detailed discussion of the points raised in this section, see Kaul and Conceição (forthcoming).

[2] The term "good" is being used here to refer to things and services as well as conditions or circumstances like law and order or peace and security.

[3] Nonrivalry means that one person's use or consumption of a good does not diminish its availability for others. This holds for goods that people like to enjoy, say the sunshine, as well as for goods by which they may be involuntarily affected, say an infectious disease. Nonexcludability exists if it is infeasible or undesirable to exclude other persons from enjoying or being otherwise affected by a good.

many other public goods have become global, or significantly more globalized, only with the greater openness of national borders. Public health is an example. The result has been that more and more global public goods (GPGs) now figure on top of national and international policy agendas.

As public goods constitute one of the main potential justifications for state intervention, form one of the main deliverables of public policymaking, and thus, are at the center of PEF, the study of globalization's impact on PEF should, perhaps, start from a clarification of the concept of GPGs. This could include an examination of global issues through the GPG lens to determine their publicness. This would help create a basic conceptual platform on which to build further analyses.

2) Exploring the provision path of global public goods

Provision paths of GPGs tend to be complex. Different goods may require different types of interventions, by different actor groups, at different levels. Charting the provision path of a GPG shows the key actors and stakeholders; their incentives and motivations to cooperate; and the links to be forged between public and private inputs as well as national and international-level interventions.

For a desired GPG (e.g. "HIV/AIDS controlled" or "greenhouse gas emissions reduced) to emerge, corrective action often has to happen in all countries. Most global public goods follow such a summation process. As figures 1 and 2 illustrate, national public goods, in this case, constitute the key ingredient of the GPG, complemented by international-level, intergovernmental inputs as well as private and civil-society inputs.[4]

Figure 1 and 2 close to here

Provision path sketches may also reveal that current institutional arrangements for public policymaking and governance need to be complemented by new institutional arrangements. At present, public policymaking is mainly organized along two fault lines: geographic (local/national/international-level) lines; and economic-sector (agriculture, health, industry etc.) lines. Adequate GPG provision may call for issue-focused public policymaking—institutions that act as issue-managers, drawing together action in different sectors and at different levels so that the desired good emerge.

3) Clarifying the differences and synergy between global-public-good and foreign-aid challenges

[4] Hirshleifer (1983) introduced the notion of an aggregation or provision path of public goods. He distinguished three main provision paths: 1) the summation case—where, as noted, the good emerges from a series of concerted individual contributions; 2) the weak-link case—which is essentially a summation process but one that contains a weak link so that the overall availability of the public good (say, flood protection) depends on the contribution of the weakest link (say, the weakest-link's contribution to the construction of a dyke); and 3) the best-shot case—where a single actor (e.g. a researcher) can single-handedly provide a public good (e.g. a new pharmaceutical technology).

Once one recognizes the GPG characteristics of many of today's global challenges, it also becomes evident that much of operational international cooperation does not constitute as what it is usually labeled: It is not foreign aid or development assistance but international cooperation in one's own self-interest. Rather than forming part of the equity or social welfare/transfer branch of PEF it would more appropriately be seen as the international arm of the efficiency or allocation branch of PEF. It is not primarily motivated by concerns about poor nations or poor people, but rather about enhancing one's own welfare and utility—crossborder cooperation in enlightened self-interest.

PEF's international equity branch already exists for over six decades, known as foreign aid or official development assistance (ODA). For many years, it formed the main operational part of international cooperation. To the extent that GPGs like HIV/AIDS or climate change began to call for operational international cooperation, policymakers initially responded in a pragmatic way: They simply used the already existing foreign aid system for this purpose. At present, about one-third of ODA money flows into GPG provision: that is, purposes, which also bring benefits to donor countries (see, for example, Raffer 2004).

Conflating foreign aid and GPG provision could undermine the efficiency and effectiveness of both activity sets. Thus, it would be important fully to understand the differences as well as synergy between GPG and foreign aid provision. To illustrate this point, table 1 indicates some of the likely differences between these two strands of international cooperation that studies on this topic might explore.

Table 1 close to here

4) Understanding public-private partnering at the international level

International cooperation has conventionally been of a multilateral, intergovernmental type. Today, it is changing towards becoming a multi-actor process. Both state and nonstate actors are contributing, sometimes on their own, and other times in the form of public-private partnering. Figures 3 and 4 show respectively, the growth in financing arrangements supporting international cooperation and the growth in global public-private partnerships (GPPPs), some of which may also be financing mechanisms.[5]

Figures 3 and 4 close to here

To a large extent, new actors and institutional mechanisms have emerged spontaneously on the international cooperation scene, often without an underlying theory and systematic understanding of their comparative strengths and advantages. We also do not yet know to

[5] Public-private partnerships are joint undertakings of state actors and nonstate actors (like business or civil-society). Many have the legal status of a nonprofit organization; some are for-profit entities; and and yet others may prefer to form just a lose association. Examples of public-private partnerships that address global issues and are referred to here as GPPPs are the Global Fund to Fight AIDS, Tuberculosis and Malaria (GFATM), the Galileo Project, and the International Organization for Standardization (ISO). For a more detailed discussion on GPPPs see Kaul (2006.b) and the inventory of GPPPs available on www.thenewpublicfinance.org/ .

what extent the emergence of the new arrangements is attributable to the greater involvement of private and civil-society actors; and to what extent it may have been prompted by the new and different purpose of international cooperation, i.e. GPG provision and the greater issue-focus which it creates. These and other related questions form a rich but as yet largely unexplored field of study.

5) Fostering policy research and development

In a number of policy areas we can see new policy approaches and instruments, including new financial products being developed. If they prove to be effective and efficient, they could help correct earlier or current market failure, and eventually, permit governments to withdraw from some policy areas or limit their role in these areas to more light-footed intervention. Examples of the new types of policy approaches and instruments include such as advanced purchase commitments; the International Finance Facility (IFF); the creation of carbon markets; GDP-linked bonds; or weather insurance.[6]

Many of these tools are still in an experimental stage. Yet some seem to hold considerable promise. According to Kaul and Conceição (2006), employing these tools could make meeting today's major global challenges not only more affordable but also more effective.

Thus, it might be interesting to take stock of promising new policy ideas, notably innovative financing arrangements; assess their desirability and feasibility; analyze how to move them from innovation to adoption; and examine how their mainstreaming might change current PEF theorems, including, perhaps, even the theory of market failure.

6) A changed role of the state?

Addressing global challenges effectively and efficiently may also require revisiting the current notion of sovereignty: It may call for a shift from "exclusive policymaking sovereignty" to "responsive policymaking sovereignty", with the latter implying that states formulate national policy priorities and strategies taking the outside into account.

Again, it seems this shift is already under way in actual policy practice. Global and national policies are increasingly moving in tandem, one echoing the other. The literature on issues like "deep integration" bears testimony to that.[7] Have governments already moved away from the model of the Westphalian state? Do they now act more as intermediaries (or brokers) between domestic and external policy demands? A positive response to these questions would imply a profound change in the role of the state. And while such change would be desirable from a global viewpoint, it would entail fundamental consequences for democracy; the aggregation of national preferences that we expect governments to undertake; and the conceptualization of international cooperation.

[6] For a brief description of these and other innovative financing instruments, see the Inventory of International Financing Mechanisms and Tools at www.thenewpublicfinance.org/.
[7] See, for example, Bandura 2005; Bryant 2003; and Kaul 2006.a.

These issues, too, point to a long and rich agenda of research. They go right to the heart of current standard PEF theory—including Samuelson's condition of an efficient provision of public goods, as discussed in Kaul and Conceição (forthcoming).

7) Governments' preference for subsidiarity and international cooperation *within* national borders

Closely linked to the foregoing point is governments' preference for subsidiarity. As figure 5 shows, states evidently prefer to deal with global issues, first, through domestic public-policy action; then, through the private sector, notably the integrating markets; or through temporary mechanisms (like GPPPs)—rather than through intergovernmental organizations. This finding once again suggests that a large amount of international cooperation seems to occur within or behind national borders rather than just beyond national borders.

Figure 5 close to here

Yet the common understanding of international cooperation still is that of a policy effort occurring primarily beyond national borders, at the international level, in the external or foreign realm.

Standard PEF theory usually says little, if anything about international cooperation, i.e. collective action at the international level. They leave this issue area mainly to international relations scholars. However, international relations theories focus on *inter*-national relations between states primarily. And international economics, too, has its main focus on the international realm, and mainly on issues of crossborder trade, finance, and migration and less on other GPG concerns.

For an adequate understanding of GPG issues and public policymaking under conditions of globalization and policy interdependence, it might thus be important to explore how international cooperation functions at present, and how it could perhaps be made to support better more balanced, sustainable globalization. The questions to examine might include such as: When to foster international cooperation at home, within national borders, and when cooperation abroad? How does national-level collective action in support of public goods differ from that at the international level? Does international cooperation abroad differ depending on the issue it seeks to support—i.e. depending on whether it foreign aid, more conventional foreign-affairs concerns, or GPG provision?

II RETHINKING PUBLIC ECONOMICS AND FINANCE THEORY: POSSIBLE NEXT STEPS

The foregoing list of topics shows that globalization's impact on PEF might be far-reaching. In particular, it suggests that it could be desirable to envision a new sub-field of PEF, adding to local PEF and national PEF a sub-discipline of global PEF, which would examine global issues in their globality, covering national as well as international levels of policymaking.

Considering that so far, PEF theory has usually responded to change in policymaking realities, could one assume that this time, in response to greater openness and the greater importance of GPGs such an alignment will also happen—on its own?

It could be argued that in previous episodes of change, PEF revision had its advocates—national governments in earlier decades, and the business sector when policy changes due to the recent privatization trends had to be incorporated. But who might be advocates of aligning PEF theory to greater economic openness of national borders?

A closer look at the nature of the revision exercise itself may help us answer these questions.

1) The Case for a Global, Multi-disciplinary Research Initiative

Revising PEF theory is a GPG itself. It would provide a new, improved knowledge platform for all potentially interested scholars and policymakers, public and private, national and foreign. Because of its GPG character, the suggested revision may suffer from collective action problems. Change may continue to occur primarily in selected issue areas, on an experimental basis, and often, perhaps in response to urgent policy challenges and crises. It may be incremental and slow; the advice offered by PEF and related disciplines lead to ineffective and inefficient policies and entail high costs for the world.

If the purpose of updating PEF theory would not only be to understand how PEF works at present, but also how to improve its functioning and make it more supportive of balanced, sustainable economic growth and development, the revision should lead to a theory that finds global acceptance. It might need to recognize that international cooperation has to happen voluntarily; that such cooperation will be successful where it makes sense for all; and that this condition is likely to be met where cooperation entails at least on the whole, clear and fair net-gains for all. Moreover, it could be argued that in the case of GPGs, international cooperation must be successful, because of policy and consumption interdependence. If international cooperation fails, GPG provision will suffer, affecting adversely the welfare of those who demanded an enhanced provision.

Formulating a global PEF theory to guide international cooperation in support of GPGs would thus best be organized as a global competitive research and policy review process.

Considering the rich literatures that have emerged in particular GPG areas and the fact that an overarching, general global PEF theory should be applicable to a range of issue areas, it would also be desirable to organize the revision as a multi-disciplinary process, including not only PEF sub-disciplines like global health, environmental, trade or peace economics, but also scholars from related disciplines like international relations or international economics as well as policymakers.

2) The European Commission: A Well Positioned Convener

The classical, nationally-oriented PEF theory has strong European roots. Its evolution benefited from important contributions by such scholars as Knut Wicksell and Richard and Peggy Musgrave. Moreover, Europe possesses an extensive theoretical and empirical knowledge-base about transnational public policymaking.

Thus, the European Commission (EC) is, perhaps more than any other actor, qualified—and expected—to assume a lead role in reviewing PEF theory from the viewpoint of globalization. Supporting such an initiative would also be in line with the EC's own concern about clarifying the EU's position on key global challenges, and doing so, through fostering international cooperation in the field of science and technology. The suggested PEF initiative would create an analytical and integrating policy framework for these and other EC activities and goals.

3) Possible Next Steps

To explore further the desirability of a PEF review, especially to gauge the interest of potential participants, the concerned EC directorate (e.g. the DG research) could organize a seminar of PEF scholars (including among others, PEF textbook authors, scholars from PEF sub-disciplines, notably global environmental and health economics, and international relations and international economics scholars), as well as representatives of concerned professional organizations (like the International Institute of Public Finance—IIPF).

The initial meeting might lead to the formation of a global network of PEF scholars that through cooperative research programs and global research competitions could help advance a new understanding of the economics and financing of international cooperation.

Conclusion

This paper argued that globalization has significantly changed the practice of public economics and finance (PEF). It illustrated the types of topics that might need research and debate to close the current gap between PEF practice and finance, a gap that has notably arisen in respect to policymaking on global issues with global public good properties. The analysis suggests that a revision, or perhaps more correctly, expansion of current PEF theory would best be organized as a global, multidisciplinary project; and that the EC might be well positioned to lead such an initiative.

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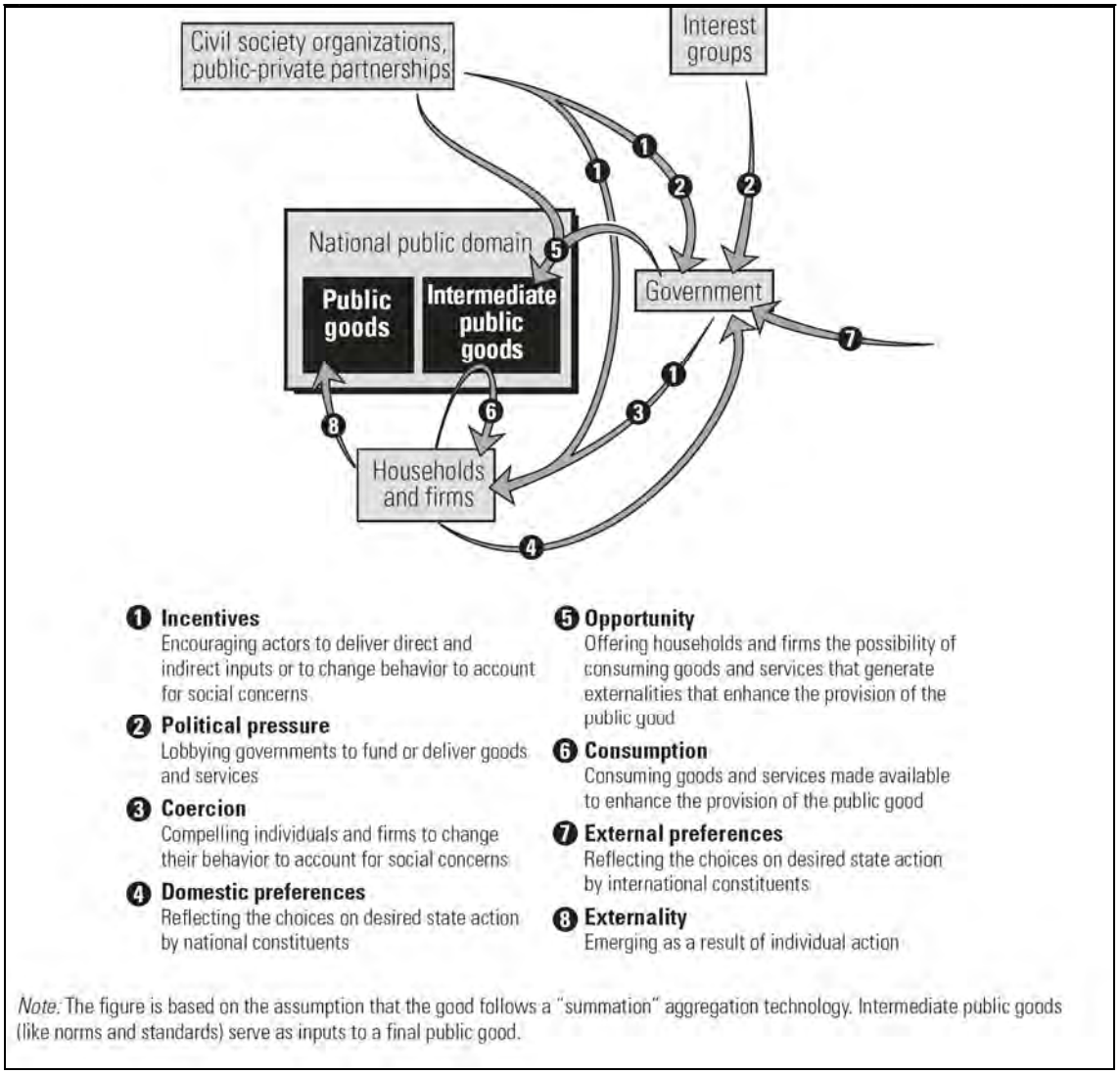
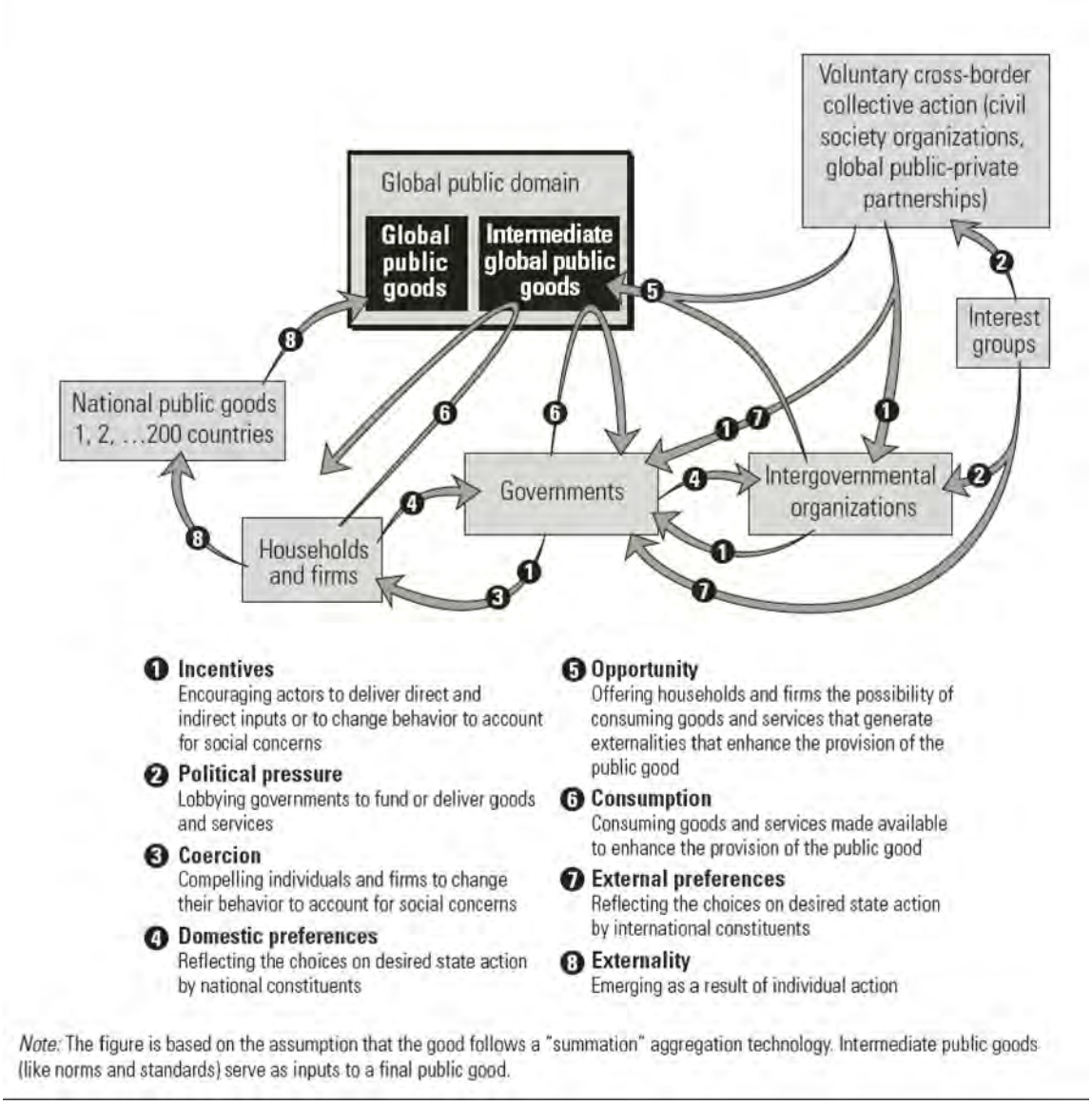
Figure 1: The Production Path of National Public Goods



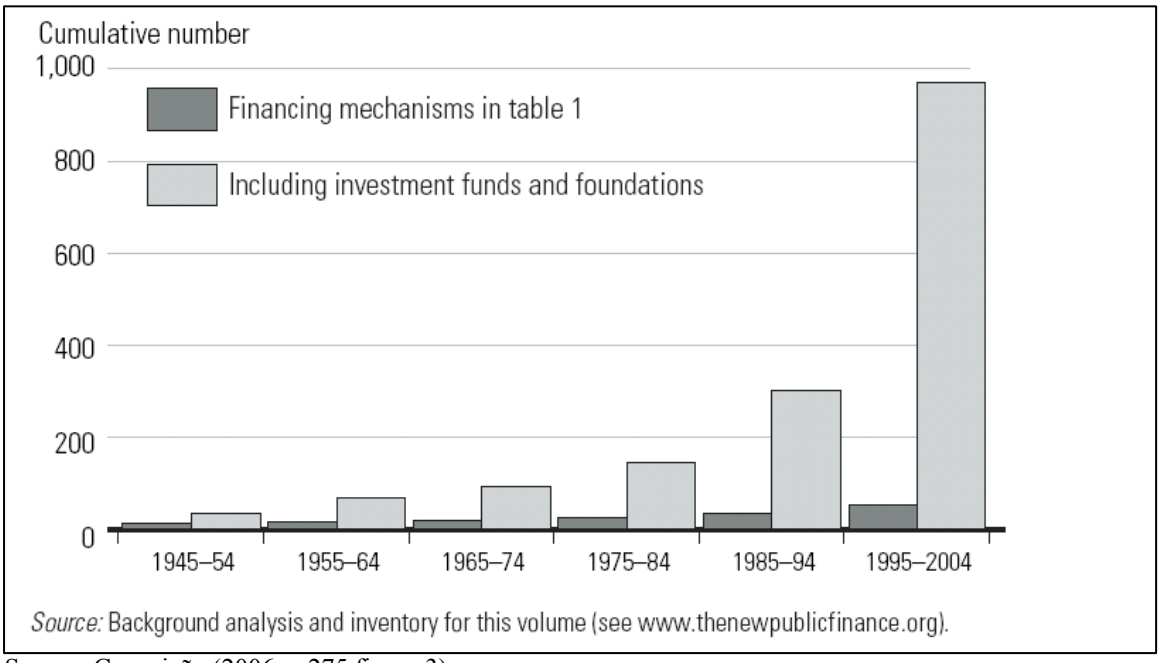
Source: Kaul and Conceição (2006, p.12 figure 3).

Figure 2: The Production Path of Global Public Goods



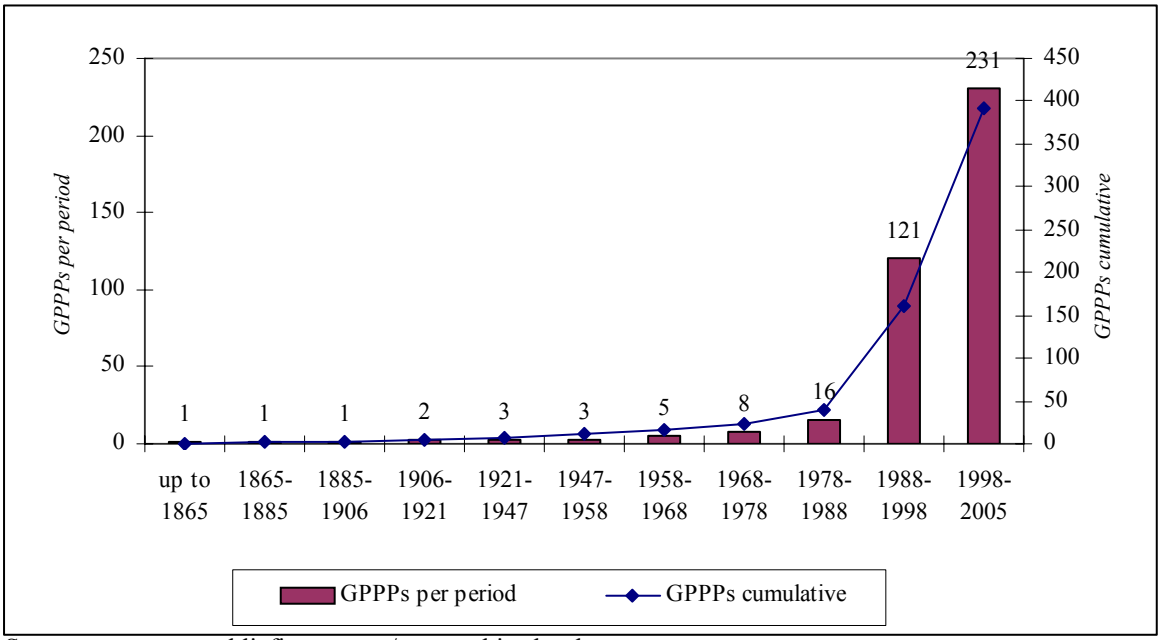
Source: Kaul and Conceição (2006, p.14 figure 4).

Figure 3: Cumulative Number of Financing Mechanisms, Including Estimates for Foundations and Investment Funds



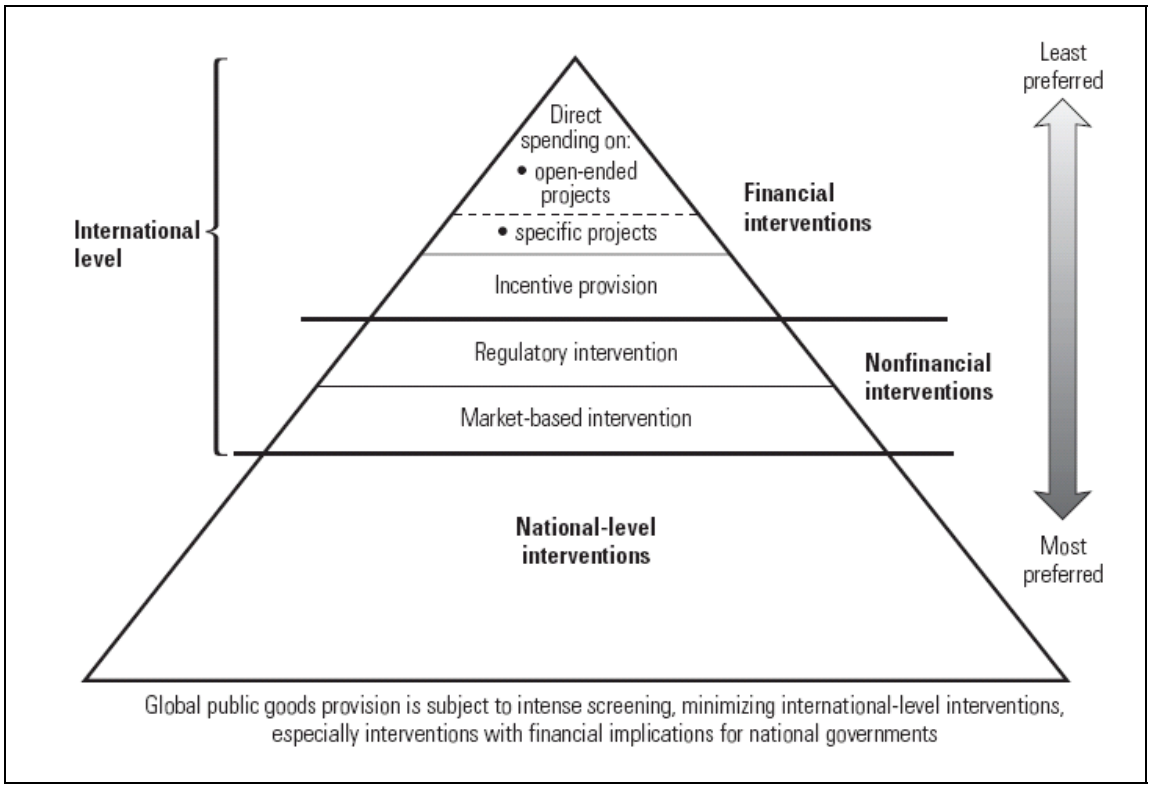
Source: Conceição (2006, p.275 figure 3).

Figure 4: Rise in the Number of Global Public Private Partnerships



Source: www.newpublicfinance.org/partnerships.html.

Figure 5: Hierarchy of Policy Interventions to Provide Global Public Goods



Source: Kaul and Conceição (2006, p.41 figure 4).

Table 1

Differences between aid and the provision of global public goods

Dimension	Aid	Providing global public goods
Rationale	Equity (poverty reduction)	Efficiency (global/national welfare enhancement)
Branch of public finance	Distribution	Allocation
Focus of policy intervention	Poor countries	Global public goods
Main net beneficiary	Poor countries	One self, and potentially, other countries, perhaps even all countries and all generations

The American Research Area and Beyond: A Transatlantic Perspective

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The United States is a key interlocutor for the European Union in the field of science and technology policy and typically serves as the comparative benchmark when discussing EU efforts in that policy arena. The strength of the American research area lies in its federal funding, the engagement of the strong American university system which competes fiercely for research support, the role of the private sector which benefits from the federal monies which are spent in this area, its openness to researchers from around the world, including Europe, and the ability of researchers to move from one research site to another as their careers warrant.

The fact that the US now enjoys a single market, a national language, research institutions which compete fiercely for top researchers and the funds they bring with them, the cooperation of private sector researchers with those in the public or not-for-profit sector, and a reputation for research excellence helps it play a crucial role in the shaping and trajectory of global research in both science and technology.

These strengths help explain why the US is a global actor in the field, one which interacts with researchers in numerous countries throughout the world, including in European states. The points of tension with Europe are fact at least partially due to the fact that the US is a global actor whereas the EU is still building its own EU-wide research area.
Although the American research area is almost fiendishly complex, three factors are particularly crucial in shaping its contours:
1) the role played by the federal government 2) the role played by the institutionalized world of science, government, and universities and 3) the role of the private sector. Those three arenas account for the institutional complexity of the American research area.

The Role of the Federal Government

The US is a federal state with a governmental structure which divides powers between the legislature and the executive rather than fusing it as is common in European parliamentary systems. The federal level of government—Washington--plays a crucial role in funding and shaping research in science and technology. The term federal government in this case refers to the executive under the President,[1] the US Congress which is constitutionally in the driver's seat when deciding funding levels, and the various entities such as national laboratories which the federal government owns and finances.
In general, the term "science policy" in the US is defined as issues related to the support of the federal government for basic and applied research rather than including issues of

[1] In the US, the President is the head of the executive and the head of state, but s/he is not the head of government. The US in fact does not have a head of government (except arguably in terms of war) as understood in traditional European parliamentary systems.

technology development (Stine, 1986). When technology is to be included, the formulation used is that of "science and technology" policy, so that the support of technology is not automatically assumed under the rubric of science policy.

Congress plays a critical role in deciding the extent of government involvement with science policy. As a major study of science policy in the United States concluded:
Congress plays a special role in allocating money to science because its legislative committees are responsible for setting the budgetary constraints for the various Federal research programs. Incentives and disincentives established by the Federal Government—such as tax credits—also play a major role…by influencing the amount of support given science by the private sector. ….such budget decisions have had profound effects upon the conduct of basic and applied research in this country" (Stine, 1986, p. 1).

Institutionally, the responsibility for science and technology was awarded in 1975 to the Committee on Science and Technology within the House of Representatives (where all spending bills must originate) after the committee was given new jurisdiction over energy, environmental, atmospheric and civil aviation research and development. Currently, its subcommittees cover space and aeronautics, technology and innovation, research and science education, and energy and environment. In essence, the committee has very considerable oversight over non-military research and development.

The importance of Congressional action has been dramatically highlighted by its intervention in the fusion energy project (known as ITER) which involves the European Union, Russia, China, South Korea, Japan, India and (at times) the United States. Although the US was one of the original founders of the project, in 1997 a Congressional decision to leave the project was implemented in 1999. The US then re-joined ITER in 2003 and in November 2006 signed the Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project (US Department of Energy, 2006). However, in December 2007, in order to avoid a presidential veto of the budget for fiscal year 2008, Congress cut the budget for ITER to zero from the $160 million originally designated for ITER by the Department of Energy. Furthermore, Congress specifically forbade using other funds in the Fusion Energy Sciences for the international project.

In general, Congress has privileged expenditures for domestic research programs in the area of fusion to the detriment of ITER (Kintisch, 2005). At the time of writing, in spite of the fact that President Bush has proposed to resume funding ITER, it is not at all clear that Congress will permit the US to commit itself to an international effort in the field of nuclear fusion (Chang, 2008).

Numerous political pressures thus enter the policy process in the making of science and technology policy. The extraordinarily pluralistic nature of the American policy-making process ensures that "universities, private laboratories, high technology industries, and government R&D organizations" (Kraemer, 2006, p. 56) will all have a voice as will members of Congress.

The Dispersal of Research Within the Federal Executive

The research initiatives carried out by the federal executive are dispersed among a myriad of organizations and agencies. There is no equivalent of a Ministry of Research. This dispersion has historic roots. As Dupree pointed out in his history of the role of science in the federal government in the pre-World War II period, "scientific institutions within the government gradually solidified into a permanent establishment" (Dupree, 1957, p. 3). That establishment became larger during World War II and expanded still further in the post-WWII period, but it retained its fragmented and decentralized character.
Research is therefore funded by a whole host of agencies, and inter-agency coordination is weak. Furthermore, the role of the federal government in the development of technology is not always direct. Sylvia Kraemer has pithily summarized the complexity of the federal government's role:

The U.S. science and technology policy "toolkit" thus consists of a decentralized and pluralistic array—some might call it a hodge-podge—of funding and regulatory policy devices, not all of which could be ascribed to science and technology policy objectives per se (Kraemer, 2006, p. 54).

However, three institutions within this universe stand out: 1) National laboratories and technology centres under the US Department of Energy (DOE) which itself had a budget of $24 billion in fiscal year 2008 2) the National Science Foundation, and 3) the National Institutes of Health.

National Laboratories
The system of national laboratories in the United States is perhaps emblematic of both the federal government's support of research and of the interdependence between government, universities, and the private sector which is the mark of American science and technology policy. Peter Westwick argues that

the resources of the labs gave [lab scientists] the power to shape the terrain of science, to build up certain disciplines and neglect others: the government…contracted their operation to industrial firms, universities, and university consortia, and thus promoted a hybrid of public and private institutions (Westwick, 2003, p. 3).

The original national laboratories were created during World War II (although the Lawrence Berkeley National Laboratory was established in 1931) and were placed under the oversight of the Atomic Energy Commission (which was established in 1946) in the post-war period when their numbers were expanded and their research mission was defined as carrying out both classified and basic research. [2] Although originally involved in research on nuclear weapons, the labs had an impact in a variety of fields, including a key role in the development of scientific computing (Seidel, 1996, pp. 33-39).

The current twenty-four research laboratories and facilities are currently under the Department of Energy and, while still carrying out research relevant to national defence, are

[2] For a history of the Los Alamos National Laboratory, famous for its role in the construction of the atomic bomb, see Hoddeson et al. (1993, pp. 56-76); for a history of the Lawrence Berkeley Laboratory see Heilbron and Seidel (1989).

also contributing to basic science as well as to research linked to environmental and energy issues. They constitute one of the largest institutionalized research systems in the world. In fact, "the US Department of Energy Office of Science leads the world in the conception, design, construction, and operation of large-scale research facilities" (US Department of Energy, 2007, p. 6). The funding provided by the Department of Energy is particularly important in the physical sciences, and the laboratories are still administered by either private companies or universities. In fact, the relationship between the labs, academia, and the private sector can be viewed as emblematic of that same relationship in the American research area.

National Science Foundation

The National Science Foundation for its part, is not incorporated into a government department. It is an independent federal agency with a budget of roughly $6 billion and funds roughly twenty-percent of university-based basic research. Its funding is particularly important in the fields of mathematics, computer science, and the social sciences. It focuses on science and engineering outside of the medical sciences. As of mid-2003, it's provided funding for 40% of non-life-science basic research at US universities. It is able to make roughly 10,000 awards per year which are submitted by the science and engineering research and education communities, with grantees being selected after rigorous peer review (National Science Foundation, 2003).

National Institutes of Health (NIH)

The National Institutes of Health play a preeminent role in the public financing of the medical sciences. Dating back to 1930 and the Ransdell Act which marked the beginning of important public financing of medical research, the role of the federal government has progressively expanded in this field. The National Cancer Institute was established by Congress in 1937, and the 1944 Public Health Service Act followed the pioneering example of the National Cancer Institute by providing research monies for nonfederal scientists.

In 1947, NIH began granting research monies to non-American scientists abroad, thereby initiating NIH's international reach. NIH became characterized by a tight linkage between basic and clinical research, a characteristic of today's institution. Various new institutes were funded by Congress over time with the result that NIH now includes 27 institutes and centers. With a budget of roughly 28 billion dollars, it is the most important funder of both basic and applied research for universities, and its role in the life sciences research community is both iconic and preeminent.

Science, Government, and Universities

The American research area incorporates a highly institutionalized relationship between government and universities. Universities are comparatively well off and spend roughly twice as much per student as the OECD average. Enjoying world class libraries and laboratories, they carry out much of the research funded by Washington or by other funders such as foundations and private firms. Universities are the crucial interlocutors of American science, whether through their own research activities funded by a diverse set of financiers or through their contracting activities with the national laboratories.

American universities can be either public or private and are not part of the state sector as understood in Europe.

They are not directly administered by government institutions. There is no equivalent to a Ministry for Higher Education, for example. The Department of Education in Washington does not oversee universities which inhabit the so-called "third sector" whether they are

publicly funded by sub-federal government (known as state governments) or are privately endowed. Public universities, even those receiving a great deal of research money from Washington, are under the oversight of state executives and states legislatures (which provide their basic funding). However, their actual governance is undertaken at arms length from political or administrative authorities so that the major public research-oriented universities have the flexibility to compete for research dollars. In fact, their ability to compete allows them to play a key role in shaping the American research area.

The Universities of California, Wisconsin, Michigan, Illinois, Texas, Indiana, Washington, and Minnesota are widely viewed as among the most prestigious universities in the United States. They compete fiercely for research funds from Washington, foundations, and firms. High-profile public universities are expected to win major research grants and compete successfully against privately endowed universities such as Harvard, Yale, Princeton, Chicago, Stanford, and Cornell in the never-ending quest for research dollars.

The experience of the University of California is emblematic of the role of the major public research universities in American academia. It, in fact, is arguably the very best public university in the US. It includes ten campuses of which Berkeley, UCLA, and San Diego are the best known in terms of research. The University of California system in fiscal year 2001 spent 2.95 billion dollars on research of which 52% came from Washington. 21% came from state and local governments and firms (mostly pharmaceutical companies). 20% came from foundations and the remaining 7% included income from endowment funds contributed by philanthropists.

Public as well as private universities therefore are crucial actors in the complex world of American science and technology. They compete for funds from a variety of sources and for the best talent in both science and engineering. The competition for talent is supported by the existence of a portable pension system in much of American higher education which allows scientists to move from one university to another without meeting the kinds of impediments often found in Europe when moving across national boundaries. The single market which exists in American higher education in the area of faculty employment serves as a taken-for-granted but crucial backdrop for the fierce competition which characterizes the American research area.

Public-Private Interdependence

While the federal government and universities are active in carrying out research, so too are state governments, foundations, and the private firms. The link between government, universities and foundations on the one hand and the private sector on the other is often viewed as a critical component in the development of science and technology in the US.

State Governments

State governments have become more active in science and technology development in the past twenty years, paying particular attention to university-industry partnerships. Texas, California, New York, Florida, and Pennsylvania have traditionally been the most important funders of state-level research and development. In 2007, for example, the state government of Pennsylvania signed a cooperation agreement with N. Rhine Westphalia in the hope of promoting alternative energy sources in the state.

Foundations

Foundations are central to civil society in the US. The American tradition of philanthropy dates back to the nineteenth century, with Andrew Carnegie of Pittsburgh being viewed by many as the father of American philanthropy. They play a crucial role in the area of the biomedical health sciences as well as in shaping global health initiatives, with the Gates Foundation now holding pride of place. (see http://foundationcenter.org/)

Foundations typically are often key early funders of research which is then financed in larger amounts by the federal research authorities. In fact, philanthropy has been so central to the research infrastructure that the original National Institute of Health was funded by Washington only after a philanthropist could not be found.

The Public- Private Link

The term "public science" is often used to describe "scientific research that is performed in academic and governmental research institutions and supported by governmental and charitable agencies" (Narin et al., 1997, p. 317). The link between such public science, technological innovation and economic growth has been extremely important. Narin et al concluded that "public science plays a crucial role in patented industrial technology" (ibid., 1997, p. 318).

Such a link is widespread. The agricultural biotechnology R&D industry provides an example (Oehmke, 2001). The general area of biotechnology in fact illustrates the "critical" role played by biotechnology companies "in commercializing the benefits of academic research" (McMillan et al., 2000, p. 2). So does the field of nanotechnological R&D.

The field of nanotech is emblematic of a link between public science and private industry which governments hope will bring large economic returns in the future. In 2003, the federal government adopted the 21st Century Nanotechnology Research and Development Act and funded it at a level of 3.7 billion dollars.[3] The prediction that a global market worth $1 trillion by 2015 in nanotechnological goods became widely accepted (Thurs, 2007, p. 171). On the private sector side, Merrill Lynch in 2004 created a stock market index, intensifying the focus on the role of the private sector in nanotechnology.

In December 2007, UCLA's California Nanosytems Institute announced a major partnership with NanoPacific Holdings to commercialize a new technology directed toward cancer patients. The Institute itself brought together two campuses (UCLA and UC Santa Barbara), $100 million in funding from California's state government and $250 million in federal research grants and industry funding. Thus, the commercialization of nanotechnology involves nearly all the participants of the American research area.

International Collaboration

For a variety of reasons, the American research area is internationally oriented. At the National Institutes of Health, the International Research Fellowship Program, initiated in 1958, was designed explicitly for European researchers. That fellowship program was a "Marshall Plan" for the biomedical sciences, designed to help rebuild the European research capacity that had been destroyed by World War II. Strong transatlantic bonds were forged by

[3] The funds were directed toward the National Science Foundation, Department of Energy, national Aeronautics and Space Administration, National Institutes of Standards and Technology, and the Environmental Protection Agency.

that Program, and those bonds have become embedded in the research culture of both the US and Europe.

Currently, European and American researchers collaborate in a wide variety of research programs and projects, the number of which seems to be impossible to tally since they do not form part of any official program. Furthermore, the competitive nature of the American research area encourages American universities and firms to recruit European researchers as well as to engage in transatlantic collaboration, both viewed as possibly giving US institutions a competitive edge *vis à vis* one another.

At the governmental level, the US and the EU in 2004 signed a five-year renewal of the US-EU "Agreement for Scientific and Technological Cooperation." Bilateral agreements have been negotiated between the US and Finland, Italy, Hungary, Spain, and most recently Poland, while other member-states have numerous informal contacts. The US-EU agreement involves numerous federal agencies—the National Science Foundation, NASA, the US Department of Energy, the Department of Agriculture, the National Institute of Standards and Technology, and the US Geodetic Survey.

The International Partnership for the Hydrogen Economy, focused on hydrogen and fuel cell technologies was established in 2003, and brings the US together with the European Commission, France, Germany, Italy and the UK.

In a similar fashion, in 2003, the Carbon Sequestration Leadership Forum was organized, now bringing the US, the European Commission, France, Germany, Italy, Denmark, the Netherlands, Greece, and the UK into a group with a total of 22 members. The Forum, led in the US by the Department of Energy and involving its National Energy Technology Laboratory, focuses on sequestering carbon dioxide from coal-fired plants and is key to clean coal technology, a pivotal area for addressing climate change.

That same international orientation is visible in the work of the Gates Foundation, now a pivotal force in various areas of biomedical research of particular interest to developing countries such as AIDS and malaria control. The Foundation works closely with the National Institutes of Health. For example, the Foundation has co-funded, along with the Fraunhofer Society and the Ministry of Economic Affairs of Saarland, a consortium led by the Fraunhofer Institute for Biomedical Engineering (IBMT) as part of an effort to develop an HIV vaccine. The bulk of the funding comes from the Gates Foundation, with the European institutions receiving the funding including the National Institute for Biological Standards and Control (NIBSC) in London, the San Raffaele Scientific Institute (DIBIT) in Milan, the University of Lund, and the University of Saarland. Furthermore, the Foundation will fund individual researchers from Austria, Belgium, Denmark, France, Germany, the Netherlands, Spain, Sweden, and the UK.

With its insistence that researchers within a consortium share data very early in the research process, it is attempting to reshape the way biomedical research is carried out. The early results suggest that that model will become more widely adopted by funders throughout the scientific community.

A Global Rather than Transatlantic Perspective?

The American research area, therefore, stands as both a model and a competitor for the European Union. Its institutional complexity can serve as a model because it demonstrates

that such complexity, a characteristic feature of the European Research Area, can be beneficial for the research enterprise. The national complexities which form the mosaic of the EU's research area are not intrinsically and structurally negative. The diversity of Europe can, with proper and very careful work on the part of the Commission, provide the impetus for a dynamic research area.
However, a key difference may inhibit the kind of vitality found in the US. The US regime implicitly accepts that the strongest institutions should receive the lion's share of government support. "Competitive federalism"—in which states compete with one another for resources, including the most skilled scientists, most innovative companies, and the most prestigious and research capable universities—is embedded in the American system of governance. In a similar vein, fierce and constant competition among research institutions, which encourages international collaboration and the recruitment of non-American researchers, is a defining characteristic of the American science and technology community.

Given a norm of regional equalization and the ongoing enlargement of the European Union which is accompanied by the accession of ever weaker states, it is unclear how a globally competitive research area can emerge. Research is very costly, but above all it requires talent. Whether talent can be convinced to remain in the poorer accession states is unclear. If talented scientists move to the wealthier EU members, the formation of an EU-wide research area will be at risk.

It may be that a more reasonable policy goal would be to adopt the goal of a "layered" research area. Within such an area, the wealthy research-oriented countries would be given EU support for the most technologically sophisticated research while the poorer accession states would be given support to build up their long-term institutional capacity. Such support would help convince their own talented scientists that their prospects would improve over the medium term as well as give them a direct role in the institution-building process.
Strengthening European research capabilities is crucial if the European research area is to increase its competitiveness *vis à vis* the American. Researchers are among the most mobile of workers, and their fluency in English makes emigration exceptionally easy. Not surprisingly, the "brain drain" to the US has been a featured problem of nearly every Commission analysis of the state of science and technology in the EU.

The issue of how to build a competitive research area is becoming even more urgent, however, as the shape of the global science and technology universe is undergoing unprecedented change. While the US as a competitor is a long-term feature of the transatlantic research arena, the kinds of research, for example, going on India promises to be another challenge for both Europe and the US.

A major policy shift with long-term consequences for both the EU and the US occurred in January 2005 when India adopted policies in the area of patents which are compliant with the World Trade Organization. The extraordinary acceleration of R&D expenditures by both Indian-and foreign-owned companies is striking. It is important to remember that 'India is a developing country but it is a developed country as far as its intellectual infrastructure is concerned' (Mashelkar, 2005, p. 1416).

While the EU is trying to construct a research area while viewing the US as its key competitor and benchmark, a new R&D competitor is quietly emerging. Such a re-shaping of the global competition in the science and technology arena presents a powerful impetus for a hard-

headed assessment on the part of the European Union of how to deepen its research area in an enlarged European Union in the face of a new global competitive environment.

It may be that the European research area would be strengthened if the US and EU could build a common framework to tackle specific scientific issues and invite third countries to join. Whether such a strategy would increase the cohesiveness of the European research area is uncertain, but it would increase its international orientation and perhaps most importantly link it firmly to the evolving international research arena.

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